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WARES OF THE AIRCRAFT INDUSTRY

The recent announcement that the rejuvenated Ford Trimotor is to be known as the "Stout Bushmaster" will revive memories of the famed three maxims of the designer from whom this aircraft takes its name. "Simplicate and add more lightness": "What you don't put into an aeroplane gives no trouble": and "An aeroplane must support itself financially in the air." Those are words no engineer would gainsay; they will be in the minds of many visitors this week to the annual exhibition of the Society of British Aircraft Constructors at Farnborough. Research aircraft that lead the struggle to expand the furthest frontiers of technological advance necessarily attract particular attention by the sheer technical virtuosity of those who design them. But our hopes for more immediate prosperity must rest on what is in the shop window, for sale, to-day.

Where machines are making their first appearances, comment and criticism have a clear field until the accountants of the operators give their verdict. A characteristically British commercial aircraft makes its bow this year, and a detailed study indicates the many and conflicting requirements of worldwide operation. Air-cooled poppet valve engines, familiar wherever aircraft fly for hire, supply power also to a cabin pressurisation system needed for flights over mountains and above bad weather. Many routes require complete anti-icing protection and many use small airfields. Low capital and running charges are essential, but restricted ground facilities demand easily opened cowlings, low loading height, and a steerable nose wheel. The oft-claimed genius of the British for compromise can be exercised to the full on a machine to carry a choice of loads over a variety of routes. Another stranger addresses the less subtle problem of going where other aeroplanes cannot; the proven paraphernalia of slats and flaps give it the power to work on the crudest fields. Nevertheless if it follows the ugly Junkers into the service of men whose sole practicable means of coming and going is by air, as it is in many overseas territories, it will be because of its ability to carry anything within its capacity and to do it every time and any time. The need for an aircraft for these duties is undeniable, the task of providing it exacting. Nor does the demand for value for money stop short of the military aircraft designer; a new acquisition of the Royal Navy is unashamedly built with no more than the essentials for an arduous and unglamorous application, and with a realisation that, in the task of searching wide waters, quantity is more than a substitute for quality. The aircraft has, very justly, been downgraded into a carrier of its crew and its weapons, and, in that light, economy—of manufacture, of maintenance, and of facilities—is seen to be a major virtue. But the most intriguing example of the engineer exploiting circumstances that cannot be altered is certainly afforded by the light fighter. Until military aircraft can fly with useful loads at supersonic speeds, interception with pursuit weapons is certainly a marginal matter, and any advantage in speed will be dearly bought. But manœuvrability, in particular a rapid turn on to a fresh heading, can assist immensely in an interception; moreover, it can frustrate the attempts of offensive fighters, inevitably hampered either at take-off by weight of fuel or by provision for flight refuelling, to join battle and divert or destroy the defence. And manœuvrability, as the Folland "Gnat" shows, can be bought cheaply—in fact, it carries bonuses in ease of access for servicing, strategic mobility and, compared to the conventional fighter aircraft, low cost. For the interceptor, as for the ocean patrol aircraft, low cost is very desirable, for, within the radar screen currently practicable, aircraft instantly available at the right place are needed for a successful defence. However highly a nation may value air defence, logistics exerts a stringent influence on the number of aircraft, crews, and dispersal points it can maintain. In this light, the "Gnat" is an attractive weapon, and it is also an interesting illustration of the changed problems facing modern high-performance aircraft. It is largely because the fuel, and not the engine, now represents the greatest burden of a fighter that the lighter machine can have an equivalent performance. Again, it is illustrative of the power available that the extended undercarriage is the "Gnat's" air brake, while at the commencement of World War II fixed fairings on backward-retracting undercarriage legs had to be abandoned, in favour of separate doors, because of their adverse effect on

take-off. The engine manufacturers have, of course, a strong incentive to strive for the most thrust miles per pound of fuel, for that fuel has to be carried in place of productive cargo, and fresh efforts in this direction are on show, including a compound turbo-propeller plant to offer economy to higher- and faster-flying liners, and a by-pass engine to curb the waste of energy in extreme jet velocity.

We never fail to enjoy the opportunity to study the designs and devices that result from the extreme pressures for light weight, high efficiency, and great reliability that operate in the aeronautical engineering field. The display this year, we are confident, will go some way to reassure those who have wondered whether the price paid for performance has been too great, for we can see that Kipling's " Gods of the Copybook Headings " are enshrined in the market place.

TECHNOLOGICAL EDUCATION

It is very unfortunate that the Government, in coming to a decision about the part technical colleges should play in training a very substantially increased number of students to higher technological standards, has felt it necessary to disregard the advice of the three major engineering institutions. In the *Chartered Mechanical Engineer* for September there is summarised what that advice was. The Institutions held, amongst other only less important matters also disregarded by the Government, that if the money available was to be well spent it would be better to concentrate its expenditure upon a limited number of colleges which could thereby be thoroughly equipped and adequately staffed to educate students to high standards of attainment ; and they wanted those colleges to be selected on the basis of the whole of their scientific and technological work and not only on their capacity to deal with a single technology. They felt, too, that as those selected colleges developed they ought to be allowed to achieve a considerable measure of independence of control by local education authorities and that each should emerge as worthy of granting its own awards. In our view those were sensible conclusions, widely supported amongst engineers. Instead, however, of adopting them the Government, following the recommendations of the National Advisory Council for Education in Industry and Commerce, has reverted in essentials to the scheme first put up by that Council some years ago, when the Labour Government was in power, for an award or awards open to students in all colleges. Only the proposal for a Royal Technological College to grant awards has been dropped. Instead there is substituted a Council whose first chairman is to be Lord Hives.

At first sight it must seem astonishing to engineers that the Government should so wholly disregard the advice of Institutions, which, from their very beginnings have been so interested in and so influential upon the development of technological training. But the fact is that politics and education do not mix well. If there was one scheme likely to be repugnant to a body compounded like the National Advisory Council, it was that proposed by the Institutions. For no body heavily representative of local education authorities could happily envisage a process of picking and choosing amongst the technical colleges to find a few that should be selected for specially advantageous treatment ; nor could it happily look forward to those specially selected colleges becoming almost autonomous. Educational advantages may point to those proposals as by far the best ; but political democracy demands equal treatment, or at least equal opportunity, for all ! Nor could a Government really be expected to bear the odium and the political criticism that disregard of the advice of the Council must certainly have created.

The Institutions have accepted the situation with a good grace, as, indeed, was to be expected of such responsible bodies. They have recommended their members, in their individual capacities, to co-operate with the authorities in operating the scheme. They are, indeed, to co-operate themselves. They have been invited to nominate and will nominate two members of the Board of Studies in Engineering, a Board that will be responsible to Lord Hives's Council for all matters concerned with the approval of engineering courses, standards of the awards and the conduct of examinations. It may be that the scheme is ill-conceived. The Institutions think so, and so, we think, do the majority of engineers. But the matter has become urgent. Very probably it is better to put into effect an ill-considered scheme than that there shall be no scheme at all. The attitude of the Councils of the Institutions seems in these circumstances the right one. As their Presidents remarked in a letter to *The Times* on July 20th, just after the Minister had announced the Government's decision, " At this stage we can but express the hope that the action which the Minister has taken will be administered so as to become the first evolutionary step in the direction which our Councils have so strongly advocated." Fortunately there is nothing in the scheme that must utterly prevent such an evolution.

REALITY OF BRITAIN'S ECONOMIC TROUBLES

How real, we are tempted to ask, is the apparent emergency in this country's economic affairs ? Certainly the gold and dollar reserves are ominously falling. Certainly imports and exports are out of balance. Presumably, therefore, the home demand for goods stands higher than home production. But is that condition of unbalance to be regarded as permanent unless corrective measures are taken ; or is it merely the kind of temporary fluctuation the reserves are designed to cover ? For it is altogether too simple to leap to the conclusion that wages and salaries must have been pressed up too far in relation to productive capacity. Some of the fluctuation in the reserves may very well be traceable to quite different and impermanent causes. If, for example, an industry finds its order books in a particularly healthy state it will be encouraged to increase its productive capacity, and so to increase its supplies of raw materials. Since it takes time to work up raw materials into finished products, imports will temporarily be more stimulated than exports. Again strikes may affect the output of an industry or affect its power to keep to delivery dates. It will be many months before it can catch up. But meanwhile, if imports have been unaffected, there will be a drain on the nation's reserves. Even a rise in wage rates, though fully justified by improved capacity to produce, may have a similar effect because it will take time for actual production to catch up on the demand.

Yet even if the explanation of Britain's present unbalance in trade can be found in such factors, the Government cannot afford to take no action. For ever since the war the amount of the reserves has never been adequate to the scale of this country's oversea trade. The mere threat of a substantial fall serves to produce a crisis which the Government must act to relieve. What is, however, strange is that in such circumstances Governments, whether Conservative or Labour, feel constrained to attack, not directly the rate of consumption at home which is the prime cause of temporary unbalance, but the rate of investment in productive plant. For, in fact, the future power of a nation to compete in export markets depends primarily upon the improvement of its productive plant ; and it must be obvious to all that it will be the nation that invests the larger fraction of its wealth in increasing its productive capacity that will the more rapidly advance its standard of living. But what is economically strange may not be politically so. Democratic Governments no doubt find it more expedient to control inflationary situations by restricting investment than by imposing wage restraint and its corollary dividend restraint as well. Perhaps, if Mr. Geddes' plea, in his presidential address to the T.U.C. has some effect and the T.U.C. makes a more detailed and perhaps more impartial study of economic matters, than it has yet attempted, future Governments will find the way made easier for them. But, we confess, we doubt it !

A Seven Day Journal

List of Centenarian Firms

IN a Centenary Number to be issued to mark the Centenary of this journal on January 4th next year there will be included a list of British manufacturing and consulting firms, institutions and societies and journals operating in the fields covered by THE ENGINEER which will have celebrated their Centenaries by January 4, 1956. To ensure inclusion in the list each such firm or society in the engineering and allied industries, the iron and steel industry, the shipbuilding industry, and any other industries whose activities are commonly reported in THE ENGINEER, should inform us about the date of its foundation, its title at that time and its present title, before September 23rd next, addressing the communication to The Editor, "The Engineer," 28, Essex Street, London, W.C.2.

Semi-Manufactures of Copper

LAST Monday, the report of the Monopolies Commission on the supply and export of certain semi-manufactures of copper and copper alloys was published (H.M. Stationery Office, price 7s. 6d.). It covers plate, sheet, strip, rods, wires and tubes, supplied as "semis" to many industries for further fabrication. The report notes that there are about 140 manufacturers, of whom seventy, accounting for more than 75 per cent of the total production, belong to one or more of twelve trade associations. Most of these associations are members of the British Non-Ferrous Metals Federation. In its "conclusions and recommendations" the Commission expresses the view that arrangements for fixing common minimum prices in this industry are against the public interest and should, therefore, be abrogated. The Commission says also that "many of the other common trading arrangements are ancillary to the common minimum price system," and as the Commission finds them to be against the public interest, it urges that they should be discontinued. Other comments by the Commission are concerned with "loyalty and aggregated quantity rebates," and with international arrangements. About the latter, the report says that the international arrangements should be looked at primarily for their effect on home prices, since the industry's contribution to the balance of payments arises mainly from its position as supplier to a great variety of export industries. The intention and effect of the arrangements has been, and is likely to be, to keep home prices up, which outweighs any possible advantage they may have for direct exports. United Kingdom manufacturers should, therefore, the Commission suggests, withdraw from the arrangements. The British Non-Ferrous Metals Federation has said this week that it will, of course, study the report most carefully. But it does not agree that the industry's practices are against the public interest.

Mast Erection Equipment for Railway Electrification Work

LAST week, at the invitation of the British Transport Commission, we attended a demonstration of a new mechanised equipment being used for the installation of the masts for the overhead structures in the electrification of the line between Shenfield-Chelmsford and Southend (Victoria). This equipment has been developed by British Callender's Construction Company, Ltd., the contractors for the work, in conjunction with Wharton Engineers (Elstree), Ltd. With it the operations of digging the mast foundations, erection of the masts, and placing of the foundation concrete are carried out at a speed far greater than is possible with hand labour as used hitherto. The new equipment requires complete possession of one set of tracks and it is carried on three separate train sections spaced some distance apart along the line. The first train section carries a diesel engine driven earth auger head, capable of boring holes from 2ft to 3ft 6in diameter up to 12ft deep. This auger head is pivotally mounted on a boom and with it holes can be bored up to 13ft 6in from the centre of the track. After a hole has been made a frame for positioning the mast is fitted over it and a shallow sheet steel lining placed round the upper part. The second train section carries a stock of masts and incorporates a steam crane which lifts and places the masts which are locked in position in the frames. The third train section is made up of cement and aggregate supply wagons at each end of a truck carrying two concrete mixers, one on each side of a concrete placing unit. This placing unit consists of a rotatably mounted telescopic jib carrying a skip which is filled from each mixer in turn and then swung out over the mast foundation and emptied directly into the hole. A power car in this section is fitted with a diesel engine generating set for supplying current for the concrete mixer motors, motor-driven pumps for feeding water from a tank wagon to the mixers, and an air compressor for feeding a concrete vibrator and other pneumatic tools. The operating sequence of the three train sections is arranged on a ten-minute cycle. Under normal working conditions the sections can complete their boring, mast placing and concreting operations in this time and be ready for moving up to the next mast position.

International Congress on Prestressing at The Hague

THE Federation Internationale de la Precontrainte held its second international congress last week at The Hague (the first congress was held in London two years ago). The papers presented at the congress were concerned with various aspects of prestressed concrete construction, and were divided into several main groups, for each of which a general report was compiled. Eight papers were discussed in the first general report by B. Kelopuu, entitled "Function of Grouting and Anchorages in the Behaviour of Prestressed Elements," and six in the second, namely, "Experience and Problems Concerning the Manufacture and Use of Steel for Prestressing," by A. S. G. Bruggeling. Precast work was discussed by D. H. New in the general report "Progress of Precast Prestressed Work in the Factory and the Assembly by Prestressing on the Site of Precast Units," which reviewed thirteen papers. It will be seen that the subjects of these general reports relate to those aspects of prestressed concrete work of greatest technical interest at the present time. On the theoretical side of structural design, the same interest was apparent in the general reports "Moment Distribution in Statically Indeterminate Prestressed Structures Beyond the Elastic Phase," by Y. Guyon, in which four papers were reviewed, and "Influence of Plasticity on the Strength and Instability of Thin Prestressed Shells," by F. Levi. This last report concerned only one paper, interest in the subject being considered a result of the symposium on shell roof construction held in London in 1952. The congress also included two "communications," on the economic advantages of prestressed concrete and on comparisons of specifications and practice in various countries.

Shipbuilding Costs

ON Friday, September 2nd, the 18,000-ton deadweight oil tanker "Heldia," which is being built to the order of Shell Tankers, Ltd., was launched from the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd. Speaking after the launch, Mr. A. S. C. Hulton managing director of the owning company, mentioned that the shipbuilders had constructed more than 400,000 tons for the Shell Group. Such a long association, he continued, was not one to be easily discontinued, and he thought it possible that after the completion of the current programme more orders might be forthcoming. He confirmed that Shell Tankers, Ltd., had been ascertaining from British shipbuilders the position with regard to building berths and prices. He made it clear, however, that inquiries had been pursued in several Continental yards, in addition to Dutch yards, where many of the company's ships had been built. The results, Mr. Hulton stated, were not favourable to British shipbuilding, for they indicated that, despite dearer steel, the Continental yards were able to build the cheaper ships. Such contracts were attractive, since the increasing cost of ships correspondingly reduced the replacement resources of the owners so that it was incumbent upon them to spend carefully. Full order books and present prosperity, he thought, tended to push into the background the dangers of the future and he suggested that now was the right time for the future problems of the industry to be collectively tackled. Such advice by owners, admitted Mr. Hulton, had been made many times before; however, the cry of "Wolf," he averred, was now of much more significance since the wolf was no longer round the corner but in full view. In conclusion he firmly maintained that, although shipowners, from many points of view, personal, commercial and patriotic, wished this country's shipbuilding to be both prosperous and competitive, they hoped that too great a strain would not be put upon their loyalties.

Obituary

HAROLD HILLIER, O.B.E.

ENGINEERS, especially those concerned with the construction of steam plant, will have learned with a sense of loss of the death of Mr. Harold Hillier, the engineering and technical director of G. and J. Weir, Ltd., of Cathcart, Glasgow. Mr. Hillier, who died on August 27th in his sixty-fifth year, was born at Barrow-in-Furness on July 25, 1891, and served his apprenticeship with Vickers, Ltd., Barrow, where he gained practical experience in all departments of the engine works. His theoretical knowledge was acquired at the Barrow Technical College, and subsequent to the completion of his studies he continued for a number of years as a teacher of applied mechanics in the same college. After completing his apprenticeship Mr. Hillier entered the drawing-office, where he was engaged in various capacities for the next eight years until 1919, when he left to become chief draughtsman of the Contraflo Condenser and Kinematic Air Pump Company, Ltd. In 1925 he became assistant manager of the company and was responsible for the design of steam

condensing, feed heating, evaporating, and de-aerating plants.

He joined G. and J. Weir, Ltd., when that company acquired the business of the Contraflo Engineering Company, Ltd., in 1930, as technical assistant to the board of directors and was later appointed chief executive engineer responsible for the design and performance of all the company's products. Some three years later he was appointed to the board and continued in control of research and design work and technical development. Mr. Hillier was a member of the Institution of Mechanical Engineers, the Institute of Marine Engineers, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders, before which he presented a number of papers which dealt authoritatively with steam plant.

In 1948 he was awarded the Thomas Hawksley Gold Medal, in the following year the Willans Premium for his paper "Feed Distribution and Hunting in Marine Water-tube Boilers." For his contribution to marine engineering, particularly auxiliary machinery, communicated in part in his paper "Scale Formation in Sea-Water Distilling Plants and its Prevention," he was awarded the James Clayton Prize in 1953. This paper and that previously mentioned were presented before the Institution of Mechanical Engineers. During the last war Mr. Hillier acted as a consultant to the Admiralty and also served on various committees dealing with weapon design, his services recognised by the award of the O.B.E. in 1943.

C. A. VANDERVELL

MR. CHARLES ANTHONY VANDERVELL, whose death occurred suddenly, in London, on August 30th, will be long remembered for his work in the provision of electrical equipment for motor-cars. So long ago as 1892, when he was twenty-one, he established a business at Willesden Green, for the manufacture of accumulators.

Mr. Vandervell, who was the son of a stockbroker, was born in 1871, and received his technical education at University College, London. In 1908 he transferred the business of C. A. Vandervell and Co. to Acton, and there rapid development was made in the production of the constant current dynamo. Just before the first world war, Mr. Vandervell began work on the production of self-starters, the first push-button silent starter being fitted to his own car. Subsequently, similar starters were fitted to tanks and other fighting vehicles. The development of ignition equipment for commercial vehicles followed, and in 1926, the business of C. A. Vandervell and Co. was merged into the Joseph Lucas organisation, in which Mr. Vandervell continued to serve as a director until his retirement in 1946.

Throughout his long career, Mr. Vandervell commanded the respect of all who knew him, for his vast technical knowledge and also for his practical application of it. He was energetic in the affairs not only of his own business but also in that of the Norton Motor Cycle Company, in which he had an interest. In his later years he became also a director of Vandervell Products, Ltd., the bearing company founded by his son, Mr. G. A. Vandervell. Mr. Vandervell's death is a great loss to the British motor industry. He was one of that industry's few remaining pioneers, and in it, as well as in other spheres of industry, he had many friends who valued his advice and assistance.

Engineering, Marine and Welding Exhibition

No. I

THE twentieth Engineering, Marine and Welding Exhibition was opened at Olympia, London, on Thursday, September 1st, by Mr. H. S. Broom, the honorary president. The ceremony was quite informal and in welcoming visitors to the exhibition, Mr. Broom said that the prestige of the British engineering industry had never stood higher in the world than at the present time. At the inaugural luncheon, Mr. Broom remarked that at the first exhibition of the series, held in 1906, there were only 100 exhibitors. The diversity of technical interest at the present exhibition had never been surpassed. Developments in engineering were taking place rapidly. In particular few could have foreseen such rapid advances in nuclear power. People were talking freely about automation, and there was also the big contribution being made industrially by electronics.

Here we present a description of some of the exhibits. The exhibition will close on Thursday next, September 15th.

ROCKWELD, LTD.

A new item of equipment which is included amongst the single and multi-operator arc welding plant exhibited by Rockweld, Ltd., Commerce Way, Croydon, Surrey, is the portable diesel engine-driven set illustrated in Fig. 1. This machine consists of a rigid fabricated sectional steel frame mounted on pneumatic-tyred wheels and carrying an Enfield horizontally opposed, twin cylinder, air cooled diesel engine rated at 15·6 b.h.p. at 2000 r.p.m. The engine is coupled to an overhung generator with a continuous rating of 250A. By using an intensive blast of cooling air from a large fan, which also serves to cool the engine, a light-weight design of generator is used on the machine.

In the extensive range of electrodes shown on the stand particular attention is drawn to the "Chromolac" series used in the welding of creep resisting steels and for

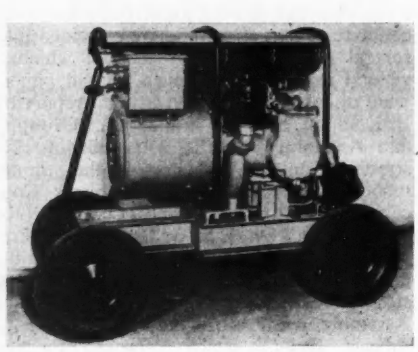
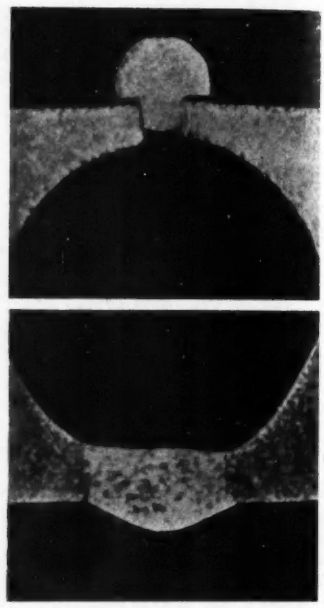


Fig 1—Portable welding set with a 250A generator driven by an air-cooled 15·6 b.h.p. diesel engine—Rockweld

the welding of "Nimonic" and similar alloys. Another interesting development of this firm is the "E.B. Root Weld Insert," which was developed in the United States for welding pipe systems carrying radio-active fluids. This insert consists simply of a wire of special cross section which is obtained by machining, cold rolling and cold drawing.

The cross section of the wire can be seen in Fig. 2 (upper) where it is shown fitted between the prepared surfaces of a pipe. In the welding procedure, the internal surface of the pipe having been purged with argon gas, the insert is tack-welded using only an argon arc torch. Completion of the root pass by playing the argon arc on to the insert and



Above: Insert in welding position. Below: Pipe at conclusion of welding operation

Fig. 2—Root weld insert—Rockweld

joint surfaces results in a capillary movement of the insert metal into the position shown in Fig. 2 (lower). The capillary forces are such that in the welding of the pipe the internal surface contour is independent of whether the weld is taking place in an overhead, horizontal or vertical position.

The makers state that an operator requires very little training for the use of this consumable root weld insert so that first-class joints can be obtained in a variety of alloy steels and in some non-ferrous alloys, without reliance on a very high degree of skill on the part of the welder. The composition of the weld insert requires careful metallurgical selection and in many cases the preferred composition of the weld metal differs from that of the metal being welded.

JOHN THOMPSON GROUP

Two companies of the John Thompson Group are showing newly developed "package" boilers. The first of these is the "Minepac" boiler of John Thompson Water Tube Boilers, Ltd., Wolverhampton, which is being developed in a range of sizes from 3500 lb per hour evaporation with working pressures up to 250 lb per square inch. These boilers are completely automatic, with all auxiliaries built in so that they can be delivered to site ready for use. The boiler shown has an evaporation of 5000 lb per hour from a horizontal flat-ended cylindrical boiler shell only 4ft 9in diameter by 5ft long. Two main flue tubes are fitted with special oil burners giving a short non-

luminous flame. A two-pass system is used to ensure maximum heat transfer and the boiler uses gas oil or diesel oil without oil heating. It can also be arranged for light residual oils.

The built-in auxiliaries—feed pump, stand-by injector, oil fuel pump and forced draught fan and motor—are all contained within an insulated casing. Electrical and mechanical automatic control panels are mounted integral with the boiler, and the controls for feed, water level and oil burners can be set and automatically held for any conditions within the operating range.

The package boiler exhibited by John Thompson (Wolverhampton) Ltd. uses heavy oil fuel and has an evaporation of 5175 lb per hour at 125 lb per square inch. Its rotary oil burner, induced draught fan, feed pump and other auxiliaries are automatically controlled from a central panel. The shell of the boiler is 10ft long by 5ft 6in diameter and one main flue is surrounded by two concentric rings of fire tubes serving as second and third passes for the combustion gases.

Other exhibits include a small twin de-ionisation plant by John Thompson-Kennicott, Ltd.; representative chemical plant by John Thompson (Dudley), Ltd., and fabricated samples of the kind of work the group is carrying out for atomic energy plants.

Tilghmans, Ltd.

The new equipment made by Tilghmans, Ltd., Broadheath, Altrincham, Cheshire, includes a recently introduced automatic casting cleaning machine to accommodate castings up to about 18in square. It is equipped with a continuous loading conveyor and is loaded and unloaded automatically without stopping. In the machine the work-

Fig. 3—Dual swing table "Wheelabrator" machine—Tilghmans

pieces pass through a 36in diameter continuously rotating barrel and are exposed to the blast from two 19½in diameter "Wheelabrator" units. By the tumbling action imparted within the barrel, all sides of the workpieces are subject to the abrasive blast and a uniform surface finish, free from foreign matter, is obtained.

A rotary table plant exhibited is equipped with a 7ft 6in diameter table and fitted with two 12in diameter "Wheelabrators." These are set at an angle to give complete blast coverage to workpieces on the revolving table. The dual swing table plant illustrated in Fig. 3 has two 3ft diameter swinging tables. With it one table is loaded, whilst work is rotated on the other table inside the plant, and beneath the abrasive blast from the "Wheelabrator" mounted on top of the cabinet. This class of plant is also available with one table only, and the complete range, which comprises ten models, is designed to handle an extensive range of work.

The firm is also demonstrating a 3ft shot blast cabinet for cleaning workpieces which can be accommodated inside the cabinet, and which is suitable for use where outputs do not call for the installation of a shot blast room or "Wheelabrator" plant.

A liquid abrasive honing plant shown utilises wet abrasive and enables the surfaces of machined parts to be finished to fine limits with speed and efficiency. Burrs, machine marks and heat-treatment scale can be quickly removed without the risk of damage to sharp edges, corners and radii. It is stated that by this method, the fatigue life of the metal is considerably lengthened and the effect of this process on sliding gears, where efficient lubrication is essential, is advantageous, due to the action of the abrasive on the component which produces minute cells in which the oil is retained.

The British Thomson-Houston Company, Ltd.

Equipment for marine and for industrial use is being shown by the British Thomson-Houston Company, Ltd., Rugby. Among the exhibits of interest to marine engineers is a model of a 5500 h.p. gas turbine, which is to replace the B.T.H. gas-turbo-alternator set and the three diesel-alternator sets at present installed on the Shell tanker "Auris."

The British Thomson-Houston Company, Ltd., is also showing a multi-motor control board—one of two similar control panels ordered by Vickers Armstrongs (Ship-builders), Ltd., for the ship No. 1027, now being built. The equipment is the starboard panel for controlling auxiliary motors and consists of an auto-transformer starter and eleven direct-on contactor starters, all the gear being grouped together in sheet steel cubicles to form a flush-fronted board. The starter units are of the withdrawable plug-in design allowing maintenance to be carried out with the minimum inconvenience; if necessary, the individual starters can be removed completely and replaced or interchanged with an identical unit.

Other exhibits designed specifically for marine applications include marine radar, and a propeller rotation indicator and revolution counter. This indicator and counter is of interest in that it constitutes a departure from the conventional methods employed for remote indication of propeller speed. "Selsyns" are used in this B.T.H. system, one such unit being coupled to the propeller shaft and the other to operate the indicating instrument. The units are connected electrically by a light five-core cable and the angular movement of the transmitter "Selsyn" on the propeller shaft is reproduced exactly at the receiver end without error. A single transmitter can be used to supply more than one receiver if necessary, so that an indication of propeller movement (and revolutions, if required) can be provided on the bridge as well as in the engine-room.

On the same stand a demonstration is being given to show the operation of a B.T.H. electromagnetic coupling alternator, two of which have been installed in the 1400-ton, twin-screw M.V. "Golden Bay" as part of the main equipment in the engine-room. At sea, the units operate as conventional electromagnetic couplings between the main engines and propellers, each transmitting 630 b.h.p. at 250 r.p.m.; in harbour, they are used as alternators (driven by the main engines), each running at 300 r.p.m. and developing 500kW, 440V, three-phase, for supplying the extensive cargo-handling machinery. In vessels such as the "Golden Bay," where the electric power requirements in dock may be very nearly equivalent to those required to propel the ship when at sea, this application of the electromagnetic coupling is of considerable economic importance in instances where separate auxiliary generating sets might well approach the physical size of the main propulsion machinery itself.

A display based on the "Magnestat" (magnetic amplifier) voltage regulator shows the voltage dip and recovery time as the load changes on a typical auxiliary alternator. Six voltage regulators of this kind are to be used for controlling the output voltage of six B.T.H. 600kW auxiliary turbo-alternators for new tankers now under construction. Saturable reactors and rectifier elements form the main components of the "Magnestat" system for controlling the voltage of alternators of any size; the regulating circuits have no moving parts.

The company's industrial control gear exhibits include a "Contector" equipment—a new development for automatic protection against "single-phasing" of three-phase motors and the dangers arising from a breakage of overhead travelling crane supply wires. An item of interest to electric power transmission engineers is the company's "RB" automatic circuit recloser for use on power lines up to and including 11kV. In conjunction with fuses, the recloser prevents temporary faults from causing lengthy interruptions of supply as it opens and allows the fault to clear before associated fuses can blow. If the fault does not clear after three operations, the recloser will automatically lock open after the fourth operation.

Hancock and Co. (Engineers), Ltd.

The flame cutting plant made by Hancock and Co. (Engineers), Ltd., Progress Way, Croydon, Surrey, includes a new flame planing machine particularly intended for the smaller firm. This machine, known as the "Hancoplane Junior," can be seen in Fig. 4, fitted with two cutting heads. It is suitable for handling plates up to 10ft wide and of any length and produces the same plate edge preparations as the firm's gantry

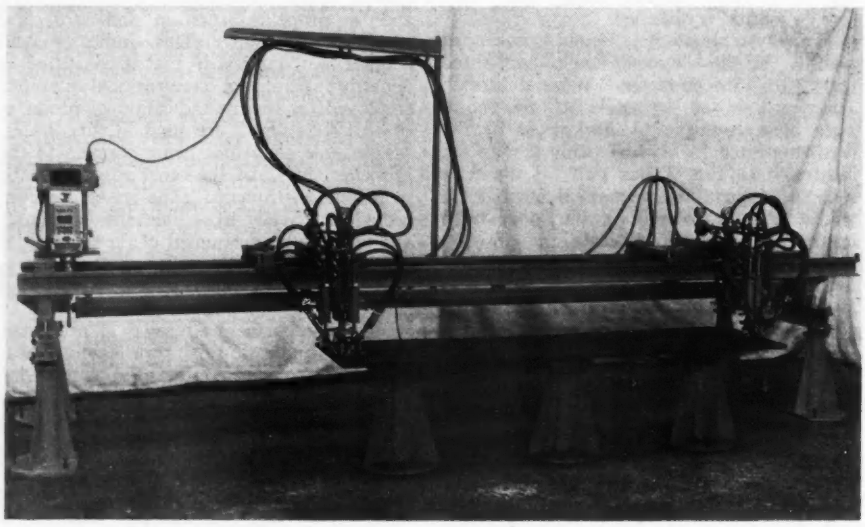


Fig. 4—Flame planing machine for plates of any length and up to 10ft wide—Hancock

design flame planer. The equipment is driven by a slightly modified form of the standard constant speed universal tracer made by the company.

A new straight cutter, shown for the first time, is adaptable for plate edge preparation, using the vertical floating head with three burners and also for automatic machine welding. It is shown equipped with an argon arc welding head and, as with all this firm's machines, a constant speed motor and variable speed drive are used to give a constant operational speed.

The "Hancomatic" oxygen cutting and profiling machine is being demonstrated with the new straight-cutting device which enables longitudinal and transverse cuts to be obtained automatically. It can be adapted for automatic profile welding and for flame planing, using the new vertical floating head.

British Moulding Machine Company, Ltd.

The moulding equipment demonstrated by the British Moulding Machine Company, Ltd., Weston Works, Faversham, Kent, is designed to show the extent to which the need for effort and skill can now be reduced by mechanised plant. One of this firm's new "BQ" simultaneous jolt squeeze moulding machines is shown in Fig. 5. The anvil of the machine is a moving assembly and when air is admitted to the jolt cylinder the jolt piston goes up and the anvil moves down against a very powerful spring. When air is exhausted from the jolt cylinder the two members come together with great force and provide maximum impaction for the sand in the moulding box. This method of jolting contrasts with the normal anvil jolt method in which the jolt table and everything on it (pattern box and sand) are raised pneumatically and then allowed to fall by gravity to cause impaction of the sand.

The machine illustrated has a net weight of 2 tons 11 cwt, and is designed to handle a large range of moulding boxes, but a nominal size would be 48in by 28in overall. The pneumatically operated overhead swing arm moves into position at the touch of a button and its movement is arrested with a minimum shock.

The pattern draw equipment is of interest, the draw mechanism being housed in the massive column where it is completely protected from sand and dust. A single cylinder and piston actuate the draw mechanism and the "gaiters," which can be seen at the back of the machine in the illustration, are fitted to the auxiliary guides. During operation the drawing assembly is guided by four hardened and ground rollers which run up and down the parallel sides of guide bars fitted to each side of the machine. The rollers rotate on eccentrically mounted spindles which provide a means of accurate adjustment and make it possible to take up wear. The duration of jolting is automatically controlled by a preset jolt timer and any number of jolts can be obtained by a simple adjustment. The makers point out that the importance of a timed jolt is becoming increasingly recognised, particularly where entirely unskilled labour is to be employed on moulding machines.

Lubrication of the machine is entirely automatic, a "shot" of oil being injected into the system each time the machine starts a new cycle. The lifting pins or frames normally fitted to a "straight draw" moulding machine have been replaced by a roller bar fitted at the front and rear of the table. The method of operation is as follows :—A cycle is started with the pattern draw mechanism in the raised position, and the empty box is rolled on to the flanged rollers from an adjacent conveyor. The box comes up against tops which position it in the longitudinal direction whilst flanged rollers control transverse alignment. The lifting carriage is lowered and the box sets on to the locating pins. The box is then filled with sand from an overhead hopper and the mould is jolted, squeezed and drawn, after which it is rolled off at the other side of the machine on to a conveyor provided with similar flanged rollers. The entire cycle can be carried out by a single operator who at no time has to lift either the empty box or completed mould.

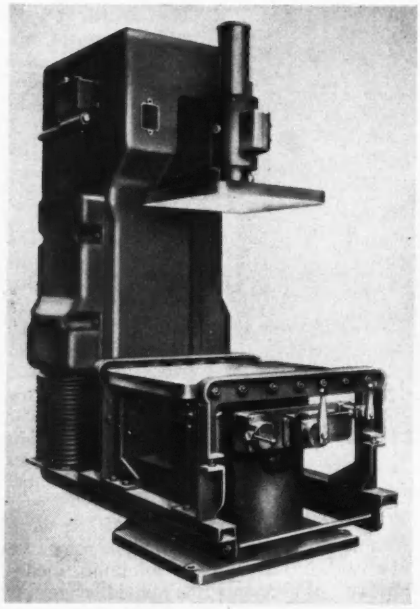


Fig. 5—Simultaneous jolt squeeze moulding machine —British Moulding

Department of Scientific and Industrial Research

The stand of the Department of Scientific and Industrial Research displays the work of the Mechanical Engineering Research Laboratory, the National Physical Laboratory, the Fuel Research Station, the Hydraulic Research Station, the Fire Research Station, and the British Iron and Steel Research Association.

The M.E.R.L. has an exhibit demonstrating the effect of truncating screw threads. The resulting higher contact pressures cause yielding of the softer component (usually the nut) and as a result the load distribution is improved, less of the load being carried by the threads adjacent to the bearing face of the nut. When the depth of engagement is 25 per cent of normal, this improved distribution is reflected in a higher fatigue strength ; the height of the nut must be 0·78 nominal diameter for the static stripping load to exceed the tensile strength of the bolt, against 0·69 D for a standard thread. Unless the crests of the bolt threads are rounded, sharp corners to the yield indentations in the nut may start fatigue cracks, but failure at loads above the fatigue limit usually occurs in the bolt. If the depth of engagement is reduced below 40 per cent of normal, the torque needed to tighten the nut increases considerably and there may be seizure between the threads. Apart from the redistribution of load, truncated threads offer the advantage of less tool wear in manufacture.

The National Physical Laboratory shows an optical method of measuring ships' propellers, and the B.I.S.R.A. a crane cab with all controls designed and arranged for instinctive operation, and a seat adjustable, it is claimed, to fit 95 per cent of crane operators.

A. Reyrolle and Co., Ltd.

The first production model of a new Reyrolle "JKSS" outdoor combined ring-main switch and tee-off fuse-switch unit is being shown. This equipment has two oil-immersed switches capable of breaking their full load current rating of 400A, and suitable for making circuit on to faults of up to 250MVA at 11kV. The tee-off fuse-switch can be supplied with cartridge fuses of up to 60A current rating with a breaking capacity of 250MVA.

As illustrated in Fig. 6, the complete equipment is enclosed in a single tank measuring 2ft by 2ft by 2ft 6in, each of the switch blades being mounted on bushing insulators through which connection is made to ring-main cable-boxes below the tank. Central post insulators carry the fixed contacts of both switches as well as one set of the fuse-switch fixed contacts, the other fuse-switch fixed contacts being supported by bushing insulators which project through the back wall of the tank into the tee-off cable-box. The blowing of any fuse causes the automatic tripping of all three poles of the

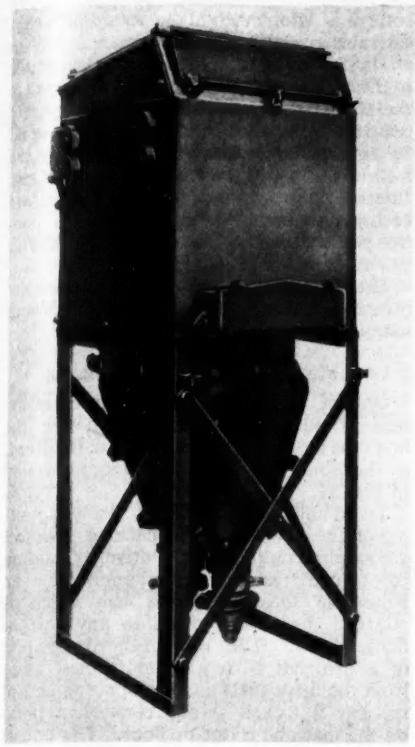


Fig. 6—Combined ring-main switch and tee-off fuse-switch unit for outdoor use—Reyrolle

fuse-switch, which has two breaks per phase. Access to the fuses for replacement is obtained by raising a small cover and rotating an internal earth shield which effectively screens off the fuses from live metal. The act of replacing the fuse and returning the earth shield to the original position allows the cover to be closed, whereby the fuses are returned to the " off " position.

The operating mechanisms are housed in shallow side pockets, those for the switches being spring-assisted, so that the speed of opening and closing is independent of the operator. Interlocks prevent slow opening of the fuse switch. The fuse-switch mechanism is spring-charged by pulling the operating handle down, the circuit being closed by returning the handle to the vertical position. Facilities are provided for earthing and pressure-testing all of the cable circuits.

Hamworthy Engineering, Ltd.

In order to show the operation of one of the " VB3 " vertical centrifugal pumps made for both marine and industrial applications, a pump on the stand of Hamworthy Engineering, Ltd., Poole, Dorset, has been sectioned and fitted with transparent plastic windows to illustrate the action of the constant running primer working in conjunction with the air separator chamber. For this demonstration air is admitted at intervals into the suction system in a manner which simulates bilge pumping conditions on ship board. The particular pump used for the demonstration has a capacity of 200 gallons a minute against 45ft total head at 1420 r.p.m., and is one of a range of sizes giving deliveries up to 3000 g.p.m. A typical example is also shown of the firm's vertical gear pumps, which are built in a capacity range from 10 to 300 tons an hour.

Pumping and heating equipment shown by the firm's oil-burning equipment division illustrates the various combinations of heaters and pumps available incorporating steam or electric heaters and steam or electrically driven pumps. These parts can be assembled as simplex or duplex sets mounted on an oil-tight foundation tray and designed for working pressures up to 1000lb per square inch. The equipment is suitable for all liquid fuels, including bunker " C " grades and creosote/pitch mixtures, and the capacities range from 250 lb per hour to 40,000 lb per hour. A duplex set exhibited has a capacity of 1500 lb per hour.

Burners made by the company are suitable for Scotch marine and other shell boilers and are supplied complete with a front plate to take the forced draught casing. A natural draught door provided to give access to the furnace has an opening of generous proportions and capable of allowing a combustion chamber design superheater to pass through without removing the complete burner.

A fuel oil sprayer has a single-piece atomiser of high-tensile nickel steel and the metal-to-metal jointing face is protected from possible damage by a raised rim. To withstand the erosive effect of the fuel oil the atomiser plate is made of special alloy and is permanently sealed in the unit. A safety shut-off mechanism prevents the withdrawal of the sprayer without first shutting off the fuel supply, and in the event of a sprayer being fitted ready for service without its " Unitip " atomiser the fuel supply is shut off to prevent discharge of fuel into the furnace.

To deal with large capacities in water-tube boilers of 250 tons per hour evaporation and upwards a larger burner has been developed. Its design is similar to that of the smaller burners, but it is complete with equipment to allow control from a centralised panel remote from the boiler. A fuel valve operated by steam or air pressure controls the discharge of fuel to the burner. After use, on shutting down, the sprayer is automatically purged by a measured volume of air or steam also controlled by the fuel valve.

Barlow-Whitney, Ltd.

A selection of process heating equipment, including ovens, humidity test cabinets, white metal melting pots, furnaces, and a number of smaller industrial heating appliances, is being shown by Barlow-Whitney, Ltd., of Neasden, Middlesex.

A white metal melting pot shown is

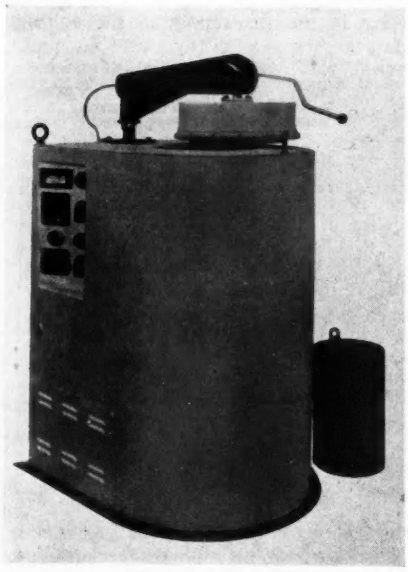


Fig. 7—Vertical forced air circulating electric furnace with removable work basket—Barlow-Whitney

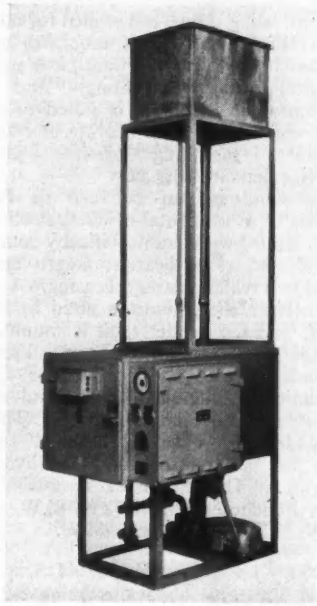


Fig. 8—Hot oil circulator—Barlow-Whitney

approximately 12in diameter by 20in deep, giving a nominal white metal capacity of 500 lb. It is of furnace construction and suitable for operating temperatures up to 600 deg. Cent. Its well-insulated cover is equipped with a simple cam-action lifting device which enables it to be easily raised and swung to one side. The automatic pyrometric control equipment, together with necessary contactor gear, is housed in a separate wall-mounting control panel. This kind of melting pot is also suitable for tempering and similar heat treatment operations with molten lead and salts, as well as for other metals.

A vertical loading electric oven is suitable for a variety of processes, including baking, curing, drying, preheating, shrinking, stoving, &c. It has been designed to eliminate the unnecessary handling of components as, by utilising a suitable overhead light gantry or runway, the parts to be treated can remain in the work baskets for several stages of the process being carried out. The oven has enclosed heaters and forced air circulation, whilst a temperature control and safety thermostat are installed. A well-insulated cover is fitted with a cam-action lever which raises and swings it to one side.

The vertical loading, forced air circulation furnace illustrated in Fig. 7 is suitable for many processes including stress relieving operations, on many types of steel, tempering and annealing non-ferrous pressings, and also for the normalising and annealing of aluminium components.

The forced air circulation gives good temperature uniformity and rapid heating, regardless of operating temperature or charge density. Designed for operating temperatures up to 750 deg. Cent. maximum, the furnaces can be arranged with steam atmosphere if required. High-quality 80–20 nickel chrome heavy section heating elements are fitted and fully or semi-automatic controls in various arrangements are available to meet individual requirements.

Electric high-temperature bench furnaces shown equipped with silicon carbide resistors have sliding doors and carborundum hearth plates. They will operate to temperatures up to 1400 deg. Cent. and have internal dimensions from 6in by 4in by 12in upwards.

The electric hot oil self-contained circulation unit being shown is designed for medium temperature applications requiring a temperature range to 250 deg Cent., low working pressure, uniform heating, and close temperature control. It is suited to operations which require the heating of extrusion machines, moulding platens, jacketed vessels, calendar rolls, &c.

The unit, as can be seen in Fig. 8, consists of a horizontal cylindrical oil vessel which is fitted with thermostatically-controlled electric immersion heaters, lagged and enclosed in a rectangular steel casing. A motor driven circulating pump is fitted below the vessel, and the header tank is mounted on vertical angle supports above. Provision is made in the pipe connections for recirculation during heating up, and special valves are fitted for this purpose. The unit is made of welded steel, and the oil tank has been tested to 50 lb (hydraulic) pressure. The circulator is available in seven standard sizes, of 6kW, 9kW, 12kW, 18kW, 24kW, 36kW and 48kW.

Mullard, Ltd.

The ultrasonic apparatus being exhibited by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2, includes a new machine tool developed in conjunction with Kerry's (Great Britain), Ltd. The machine, as can be seen in Fig. 9, is similar to a conventional vertical miller and it is fitted with a prototype 2kW ultrasonic tool. With the compound tables and vertical feed move-

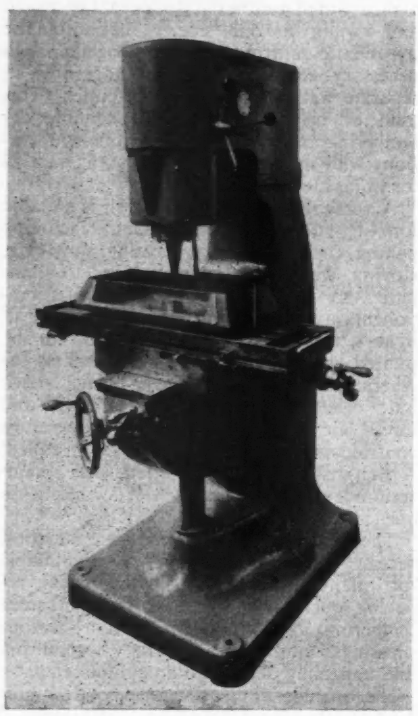


Fig. 9—Prototype 2kW ultrasonic machine tool—Mullard

ments of the machine the tool can be used in the precision machining of hard and brittle substances. With the tool actual cutting is performed by abrasive particles fed to the tool tip, and the greatly increased power input speeds the cutting of deep holes, and tools up to 2in diameter can be used.

A mechanised ultrasonic cleaning plant also built in conjunction with Kerry's (Great Britain), Ltd., is a fully automatic unit incorporating the latest Mullard high frequency ultrasonic generator and is suitable for removing loose contamination (e.g. swarf, lapping compounds, oil and grease) from such parts as ball races and hydraulic valve components. In this demonstration plant, an input conveyor belt takes the parts to be cleaned to an automatic basket-loading device, which loads and passes a 6in by 4in basket on to the main chain conveyor every fifteen seconds. The baskets pass through three tanks in succession : first, through a pre-wash tank containing trichlorethylene, then through an ultrasonic cleaning bath powered by a 2000W ultrasonic generator, and finally through a hot vapour zone for drying. The baskets are then automatically transferred to a belt conveyor at the output end.

An important part of the apparatus is a system for continuously filtering and purifying the cleaning fluid. Ferrous particles are removed by a magnetic filter, while gauze, ceramic, and paper filters remove particles down to as little as 1 micron in diameter. Oil and grease are removed by a continuous distillation process.

At the side of this automatic cleaning plant there is also demonstrated a small hand fed ultrasonic cleaning tank.

The large machine tool and the automatic cleaning system are each powered by a 2kW low frequency ultrasonic generator, the output of which is continuously variable in frequency between 10 kc/s and 30 kc/s. A high frequency generator similar in external appearance supplies the cleaning plant. Both generators are strongly constructed, being built to withstand the wear and tear of everyday industrial use. The makers state that a high margin of safety has been allowed in the design, and protection is given against overload and maladjustment.

Accurate Recording Instrument Company, Ltd.

An instrument, for use on gas-heated plant, that requires no supply of electricity, is shown by Accurate Recording Instrument Co. Ltd., Garth Road, Morden, Surrey. This device (Fig. 10) was developed in conjunction with the North Thames Gas Board and tests upon it are described in report 599/53 of the Industrial Gas Development Committee. The sensing element is a fluid-filled bulb acting through a capillary upon bellows : the capillary is 10ft long. The bellows are connected mechanically to a needle in front of a scale, visible through a window in the cast aluminium case, and also to a diaphragm valve in the gas supply to the appliance

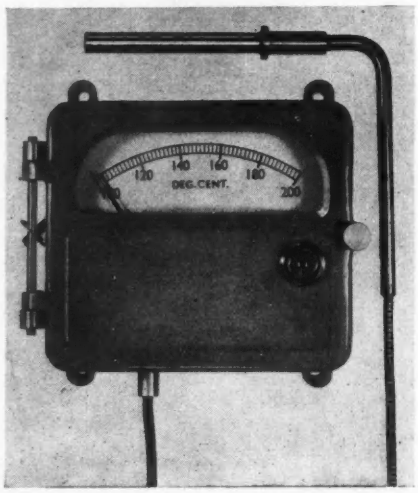


Fig. 10—Indicating thermostat for gas heated appliances—Accurate Recording Instrument Co.

controlled. A measure of proportional control is afforded, but the tests show considerable overshoot in experiments with an air heater ; this is regarded as unavoidable in the absence of an energy source other than the temperature sensitive bulb. The control temperature of the thermostat can be varied by an adjuster within the lockable case, the maximum available being 250 deg. Cent. Internal adjustments can be made to ensure accurate temperature indications at the control point. Sensitive bulbs are available with two different speeds of response.

The company's display also includes pressure and temperature indicators with various control and detecting systems.

Crofts (Engineers), Ltd.

One of the new pieces of power transmission equipment being shown for the first time by Crofts (Engineers), Ltd. Bradford, is the shaft-mounted gear unit illustrated in Fig. 11.

These units are designed for sleeve mounting on the drive shaft of a machine. No feet are required on this form of drive, as rotation by torque reaction is prevented by an adjustable torque reaction bar which is attached by stirrup plates to any pair of flange bolts. The recommended position of attachment is at a point furthest away from the drive shaft and the opposite end of the bar is locked at any convenient point on the machine frame or floor. The unit is fitted by a sleeve directly on to the machine shaft where it is securely locked by four set screws which nip the sleeve and bush to the shaft. A complete range of bushes is available to accommodate a wide range of shaft diameters and sleeves are supplied with parallel keys.

Twelve sizes of these units are available,

Fig. 11—Shaft mounted gear unit—Crofts

six of single reduction design and six of double reduction construction. The single reduction units cover powers up to 50 h.p. and when used with V-rope drives provide a range of ratios from 2 : 1 to 25 : 1, giving output speeds from 425 to 100 r.p.m. The double reduction units cover powers up to 35 h.p. and similarly make available ratios of 7 : 1 to 100 : 1 with output speeds from 125 to 8 r.p.m.

The shaft mounting gear units may be driven by a conventional floor mounted motor, or, alternatively, the motor can be mounted on the gearcase, providing a completely self-contained unit. Lugs are cast in the gearcase for the mounting of the motor

platform which accommodates any make of motor of appropriate size. With the floor mounted motor drive, motor slide rails are unnecessary, as the belt is tensioned by means of the turnbuckle on the torque reaction bar. The adjustment for units with integrally mounted motors is by means of an adjusting screw on the motor platform, which fits the standard stirrup plates of the torque reaction bar.

The units are so designed that a Crofts high-speed roller backstop, to prevent reversal of rotation of the driven shaft, may be accommodated, and an electro-mechanical over-load release mechanism may be fitted, if required. A centrifugal clutch can be incorporated in the motor pulley to enable a squirrel cage motor to be used, and this form of clutch reduces the current required on starting and provides smooth starting.

Vokes, Ltd.

A particularly arduous application for a filter is illustrated by the rock drill dust trap made by Vokes, Ltd., Henley Park, Guildford. This filter is operated by the compressed air supply of the rock drill, and it sucks airborne debris through a spoil line from the rock face. The heavier particles are centrifuged out, and the remainder extracted by a main filter element followed by a resin-impregnated wool cylinder. The cleaned air then passes out through the ejector to the mine gallery. The main filter can be cleaned by means of air jets, the dislodged spoil falling into a paper sack below the centrifuge. A depression is maintained in the trap during this operation, so that dust cannot pass back down the suction hose. The spoil sack holds about 1¼ cwt, sufficient to last a normal shift, and is long enough to be tied off before it is lifted out of the body of the trap. The air consumption, working at 65 lb per square inch, is about 30 cubic feet per minute F.A.D., and supply pressure can go up to 100 lb per square inch. The cyclone deflector plate is expected to erode, but other than its replacement no more than yearly servicing is anticipated.

Vokes, Ltd., also shows various sizes of liquid and gas filters extending to gas turbine intake sizes, and " Genspring " pipe support hangers.

George Ellison, Ltd.

An 11kV, three-phase, 250MVA circuit breaker unit (Fig. 12) which is A.S.T.A. tested and complies with B.S. 116 : 1952, is being shown by George Ellison, Ltd., Perry Bar, Birmingham. The circuit breaker is interlocked and vertically isolated and is carried on a wheeled truck which can be withdrawn for inspection, as shown in the illustration. Arc control is effected by a cross-blast system which can easily be removed to allow for inspection of the contacts. Closing of the circuit breaker can be either manual or power-operated by spring or d.c. solenoid. Single or duplicate busbars can be accommodated in the unit, with or without selector switches. Any number of 11kV units can be mounted side-by-side to form a switchboard and extensions can be made by adding further units when required.

Another exhibit shows a 660V, 45MVA switchboard which, like the 11kV unit described above, is A.S.T.A. tested and complies with B.S. 116 : 1952. The circuit breakers are isolated from the busbars by horizontal withdrawal, with interlocks to ensure that the breakers are " off " before isolation.

In addition to the electric switchgear shown on the stand of George Ellison, Ltd.,

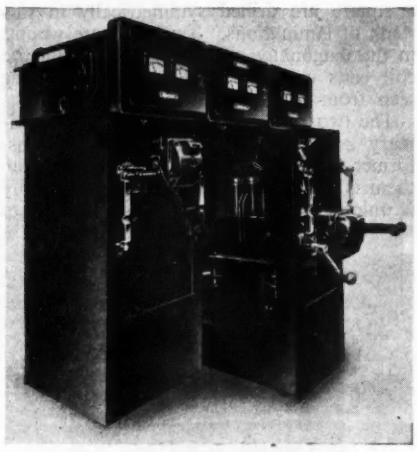


Fig. 12—11kV, 250MVA switchgear showing the vertically isolated circuit breaker withdrawn on its wheeled truc':—Ellison

there is a display of " Ellison " hydraulic valves for hand and air operation. These valves are made in standard port sizes of ⅜in, ½in, ¾in and 1¼in, and they are suitable for the control of most kinds of machinery operated by single or multi-pressure hydraulic systems of up to 3 tons per square inch, or up to 4½ tons per square inch for certain duties.

These screw-down design valves are so constructed that when a valve is being closed foreign matter can pass between the seating faces instead of becoming embedded and scoring the seat. Also incorporated in the design are simple interlocking arrangements which prevent fluid wastage by ensuring that the exhaust and inlet ports are not open at the same time.

The exhibits include a multi-way control valve with the port assemblies geared together for operation in correct sequence by a single handle. With this arrangement all valves can be closed simultaneously if required. Also shown are pneumatically operated hydraulic valves, one actuated by an air cylinder and another by an air diaphragm.

Morgan Crucible Company, Ltd.

The familiar range of crucibles, furnaces and refractories made by the Morgan Crucible Company, Ltd., Battersea Church Road, London, S.W.11, includes a recently introduced, oil-fired, hydraulically-operated lip-pour furnace (Fig. 13) with a crucible capacity of 600 lb brass. This design of furnace is made in five sizes with from 400 lb to 1680 lb brass and 1120 lb aluminium capacities.

The furnace is tilted by two single-acting hydraulic rams arranged to give a constant speed through their travel to a given control handle setting. These rams are incorporated in the trunnion pedestals of the furnace so that a minimum floor space is needed for installation and no ram pits are required. The burner tilts with the body so that firing can be continued whilst a lengthy pouring operation is taking place. Either low pressure oil or low pressure gas-firing equipment can be fitted, and the exhaust gases are taken through a branch at the back of the furnace so that operations such as charging, inspection and treatment can take place during a melt.

The furnaces are blown by a 3 h.p. fan delivering 250 cubic feet of air per minute at 25in water gauge, and arrangements can be made to blow several furnaces with one fan if required. The furnace bodies are interchangeable and they can quickly and easily be removed from their bearings and replaced by a spare during maintenance operations or when changing a crucible.

A varied range of engineering parts made from " Morganite " carbon, show the many characteristics which are available in various grades of carbon. A number of finished components exhibited include a pump shaft sealing gland, a motorised steam valve, resistance heating equipment, a submersible pump and a petrol metering device. A part of the stand devoted to the products of Morgan Refractories, Ltd., of Neston, Wirral, Cheshire, shows a selection of the refractories it makes. Of particular interest to the marine engineer, there is a section of a marine boiler wall made from " MR.60 Super " firebrick, utilising a special anchor brick and heat-resisting anchors. Other exhibits in this section include low heat storage insulating refractory bricks suitable for use at temperatures of 2300 deg. to 2800 deg. Fah., a group of " Morgan Super " refractories for specialised applications ; " Triangle " refractory sheaths and tubes, plastic and castable refractories, insulating concrete, refractory concrete, and induction crucibles.

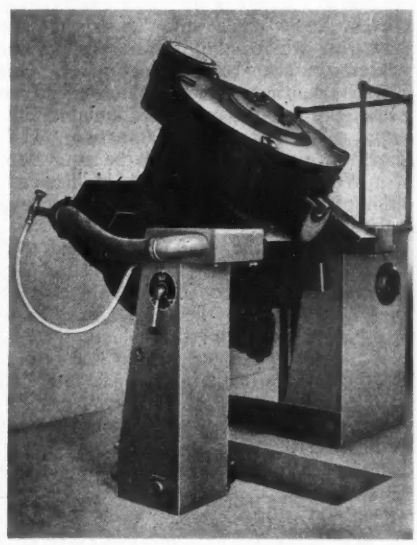


Fig. 13—Hydraulic tilting crucible furnace—Morgan

Other displays of interest on this firm's stand include a demonstration laboratory furnace utilising " MI " low-heat storage refractory bricks and a new silicon carbide electric furnace element, " Crusilite," which is available for high-temperature furnaces over the range of 800 deg. to 1575 deg. Cent. Radio components manufactured by Morganite Resistors, Ltd., Jarrow, include a comprehensive range of resistors ranging from suppression resistors for distributors and sparking plugs to heavy-duty and ultra-high ohmic resistors. There is also a selection of " Foliac " graphite-based jointing compounds, lubricants, paints and specialist greases made by Graphite Products, Ltd.

Asea Electric, Ltd.

An interesting method of stress measurement which is to be developed commercially in the near future forms the subject of two demonstration models shown by Asea Electric, Ltd., Fulbourne Road, Walthamstow, London, E.17.

The first model (Fig. 14) shows the principle of the " Torductor " arranged as a method of measuring torque. The " Torductor " consists, essentially, of two " U "-

Fig. 14—Model of a " Torductor " arranged as a method of measuring torque—Asea

shaped electromagnets with laminated cores. These two electromagnets are arranged at right angles to each other, with the common axis[1] at right angles to the axis of the shaft in which the torque is to be measured, as can be seen in Fig. 14. One of the electromagnets is connected to an a.c. supply and the other to a suitable indicator. The four arms of the two " U "-shaped electromagnets form the equivalent of a Wheatstone bridge which is in a condition of balance so long as there is no torque in the shaft.

If, however, the shaft is subjected to a torque, then principal stresses will be produced in the surface of the shaft along directions at 45 deg. to the shaft axis. These stresses will disturb the balance of the reluctances between the arms of the bridge, and the amount of the unbalance, as shown on the indicator, will give a measure of the torque. In the model demonstrated at Olympia, the indicating meter (Fig. 14) is calibrated in lb-ft to read values of torque applied to the shaft manually.

The second model shows the principle of the " Pressductor " which is essentially a pressure measuring device. The "Pressductor " body consists of a stack of square laminations glued together (Fig. 15). Four circular holes with their axes at the corners of a square are drilled symmetrically in this stack of laminations. Two coils are wound in the diagonally opposite holes so that the coil ends cross at right angles, as can be seen from Fig. 15.

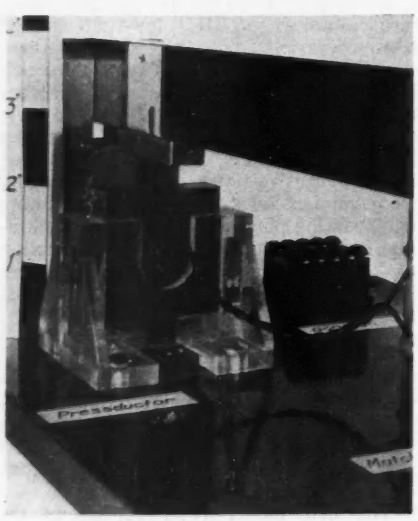


Fig. 15—A model showing the square laminated core of the " Pressductor " carrying two diagonally disposed coils for measuring pressure—Asea

The two coils can be regarded as the primary and secondary windings of a transformer, so disposed that the coupling between them is zero when the " Pressductor " core is unloaded. But if the core is subjected to compressive stress the permeability is altered in the direction of the stress and the flux distribution between the two coils is altered. If the primary winding is connected to a corresponding a.c. source and the secondary winding to an a.c. voltmeter a deflection is produced which is proportional to the force applied to the core. In the model (Fig. 16) the voltmeter is calibrated in pounds from 0 to 1200

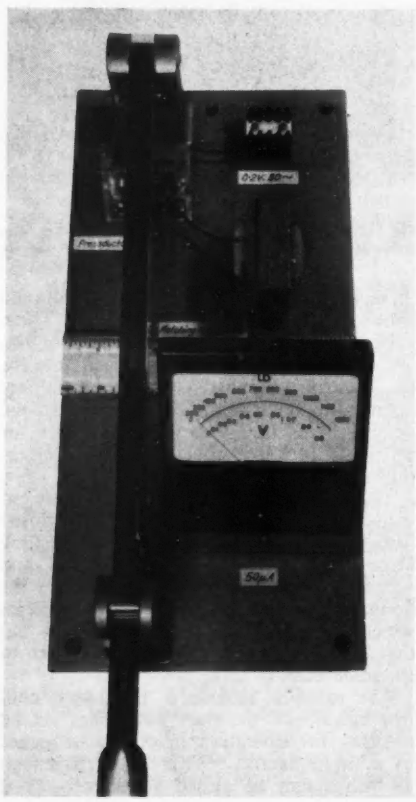


Fig. 16—A model showing the " Pressductor " arranged as a means of indicating a force in pounds—Asea

The Gas Council

A working exhibit on the stand of the Gas Council demonstrates the use of oxy-town gas for flame hardening. The automatic machine shown is used for the hardening of the surface of gear teeth, and the gears being treated are for Ruston-Bucyrus excavators. The machine, designed and manufactured by Peddinghaus of Gevelsberg and supplied by Surfard, Ltd., is capable of hardening gears up to 39in diameter and having teeth up to 9½in face width.

The gear to be hardened is supported on a vertical spigot passing through the bore. Water-cooled copper burners with spray quenchers are arranged to dwell momentarily at the bottom of the stroke and then to pass progressively up the length of the tooth. At the end of the hardening stroke the oxygen and gas are shut off leaving a small pilot flame. The burner and quench head then rises clear of the gear, which is automatically indexed to the next tooth and the head drops quickly to the starting position where it ignites and the cycle is repeated. The whole operation is controlled by a master cam in the machine.

If the gear teeth are only required to be hardened in order to resist wear, both flanks are simultaneously treated, but if required the whole of the tooth space is hardened including the root area.

A shell-moulding exhibit includes a range of metal patterns, shell moulds and cores produced in gas-fired plants, and photographs of gas-heated installations in use for producing shell moulds. Other exhibits include a new automatic coke fired boiler, suitable for heating factories, office blocks and other large buildings. This boiler has automatic feed and de-ashing equipment, and maintains constant temperatures. It is claimed that under normal conditions, this boiler operates at efficiencies in excess of 80 per cent.

Newman Industries, Ltd.

A recently introduced " gasworks " motor is being shown by Newman Industries, Ltd., Yate, Bristol. The new motor is based on the company's existing British standard dimension motor, with suitable modifications, as a result of which it is specified to be dust-tight, weatherproof and hoseproof.

The main external difference between the two designs of motor is that on the " gasworks " motor (Fig. 17) a flameproof terminal box replaces the standard box. The flameproof box has wide flanges and the terminal mounting posts are embedded in separate synthetic-resin-bonded moulded insulators. Direct conduit entry can be arranged, in four alternative positions, or the box can be equipped with a sealing chamber and armoured glands ; wide flanges or extra-long threads are provided to exclude dust. " Wiping " bearing seals are fitted in addition to the normal bearing closures. Other details are the use of studs to secure the bearing caps and the use of a lock-nut, instead of the more usual " circlip," to fix the keyed fan to the shaft.

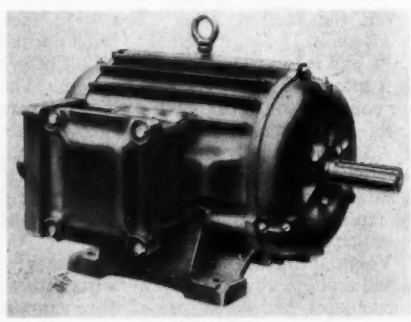


Fig. 17—" Gasworks " motor with dustproof, weatherproof and hoseproof enclosure and terminal box—Newman

After the normal impregnation the end windings are given a coat of special varnish which is highly resistant to moisture and dust. As a final precaution against dust the end bracket joints are coated with a sealing compound during assembly. The new motor is made in sizes ranging from ½ h.p. to 25 h.p.

(To be continued)

Coastal Minesweeper.—The coastal minesweeper H.M.S. " Lullington," which has a length of 152ft by 28ft. 9in beam and is armed with three small guns, was launched from the Belfast yard of Harland and Wolff, Ltd., on August 31st.

America's Approach to the Road Problem

By W. H. GLANVILLE* and R. L. MOORE†

No. II—(*Continued from page* 323, *Sept.* 2*nd*)

This article has been prepared following a visit to the United States in October and November, 1954. *An outline is given of the new road development plan for America, then in preparation, in which it is proposed to increase the* 5 *billion dollars at present being spent annually on new roads to* 10 *billion dollars, over ten years, in order to bring roads up to standards which will be adequate for the increasing traffic requirements of the next twenty years. The article outlines the means by which the estimates were obtained. The backbone of the new plan is a* 40,000*-mile trunk road network called the "Interstate System." The major road problem of the United States is the provision of adequate urban roads and parking spaces. The article shows how the design of cities is influenced by building all the roads the private motorist wants. On the subject of road safety some of the preliminary results of investigations into ways of reducing the severity of injury to occupants of motor vehicles are given. Some possible reasons are put forward for the better discipline and the decreasing liability to accidents of American pedestrians.*

Cities of the Future

THE provision of good roads and adequate marking facilities in cities and metropolitan areas is now coming to be regarded as America's most pressing highway problem.[10] Half the vehicle mileage is in these areas, and the building of great inter-city highways without complementary building of highways in the cities themselves is causing concern. Many years ago Lewis Mumford[11] maintained that the motor-car would require for its most effective use a townless highway, while the town community wanted a highwayless town. Los Angeles is commonly regarded there as being the archetype for all cities and it is interesting to see how the first part of Mumford's prophesy has been fulfilled. Here a population of nearly 5,000,000, living in one great single-storied urban sprawl, own 2,500,000 cars. The average man is said to travel 13 miles to work and to the casual visitor the city freeways carry a seething mass of vehicles travelling at high speed all day and all night. The hundred miles of freeways already built are only the beginning of city reconstruction ; a further 500 miles are needed to reduce congestion, but the convenience of a freeway is rated so high that it is said a person will drive an extra 10 miles to reach one in order to do a 20-mile journey comfortably.

The construction of freeways has wiped out large tracts of the city. To take an example, the Hollywood freeway (Figs. 4 and 5) is 10 miles long and cost 55,000,000 dollars of which 28,000,000 dollars was construction cost.[12] It is an eight-lane, limited-access road with grade separation and is used by some 170,000 vehicles a day ; it is, in fact, a townless highway. In order to build this road it was necessary to demolish ninety buildings and to move 1728—homes, apartment buildings, commercial buildings, churches and schools all had to go. If the owners could not agree on a valuation of their property it was necessary for the State to resort to condemnation proceedings. The issue in these proceedings is not whether the property shall be taken or not, but how much the State shall pay for it. Condemnation proceedings were first started in 1942 and the freeways fully opened in 1954. The total compensation paid was about 25,000,000 dollars, 5 per cent of this total being the subject of litigation. On the basis of vehicle operating costs alone, the freeway is proving a profitable investment. Tests carried out by the engineering department of the Automobile Club of California showed that automobile operation on the freeway costs 4·02 cents per mile, compared with 8·2 cents on city streets. On the basis of the present 100,000 trips daily from North Hollywood to the civic centre it has been shown that the annual saving in the cost of automobile operation is 18,000,000 dollars

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† Traffic and Safety Division, Road Research Laboratory.

Fig. 4—The Hollywood Freeway at Los Angeles looking east ; four-level interchange (shown in Fig. 3 last week) in centre; central business district upper right. The vast area devoted to roads and parking space may be noted

Fig. 5—The Hollywood/Santa Ana Freeway, Los Angeles after fifteen days of "smog"

a year. Such a return will pay the total cost of the freeway in a few years.

When visited, this city of motor-cars was having its fifteenth day of "smog." A grey, dirty mist filled the air, causing the eyes to smart (Fig. 5). This is said to be caused by automobile exhausts, the oil refineries, or the burning of domestic rubbish, polluting the atmosphere at seasons of the year when there is very little air movement.

Surveys have been, or are being, made of the highway needs of many cities. In Detroit and Chicago,[13] for example, the survey includes all aspects of transport, rail, road, sea and air, in order to obtain a comprehensive picture of the movement of the people as well as road vehicles. The Detroit survey cost 750,000 dollars; the proposed Chicago survey will cost 1,900,000 dollars, roughly 50 cents per head of population in the congested area. By the use of electronic computers the raw data of these surveys, the origin and destination of journeys made by the individuals in the community, can be rapidly translated into an optimum highway pattern. It is thought by the Bureau of Public Roads that the desirable road plans for various cities are very similar.[14] Superimposed on the present rectangular street plan it is usually found necessary to have a set of radiating roads with an inner ring road. The new roads would be freeways and would pass over or under the existing road system. In the case of a city like Chicago, bounded on one side by water, the required road plan could be regarded as being one-half of the typical layout. The old-fashioned practice of improving road systems by building fresh roads at the same level as existing roads and thus multiplying the number of intersections, was not seen in America. The new city highways are freeways and pass over or under existing roads. In Chicago[15] one of these new super-highways is under construction. It will be 8 miles long and carry eight lanes of traffic with four railway tracks in the median strip. The building of this road has entailed the clearing of a jungle of concrete and steel. Some buildings have been arcaded to make footpaths, others have been moved bodily and the thirteen-storey U.S. post office building, which stood astride the path of the road, has been tunnelled to allow the 80ft wide road to pass through.

Such reconstruction of cities is appreciated from the air when the enormous extent of new road systems can be seen in plan (Fig. 4). These changes are made possible in America by a different attitude to the city from that found in England. In England, cities, as they become older, excite in many an irrational desire to preserve them irrespective of their architectural merit, sanitary superiority or traffic convenience. In the newer cities of the United States these feelings do not appear to exist. The city is not regarded as a static organisation, but one which, in the present age of private car transport, must be modelled to suit motor traffic.

Several trends of thought are found. Some regard the central part of the city as necessary to provide the space for the special services, for the cultural activities of the city, for the shops which sell the mink coat or the Parisian gown.[16] The standardised article or the groceries can just as well be bought in the suburbs, thus lessening the demand for parking space and roads in the city centre. Many large stores have moved out, or opened branches in the suburbs where adequate parking can be provided (Fig. 6). Another school of thought believes in anchoring the downtown business and shopping area by building the necessary roads and parking

Fig. 8—A twelve-storey mechanical parking garage in Chicago; 495 cars on an 80ft by 170ft lot

facilities. The efforts being made in Chicago in this latter direction were investigated in some detail. Possibly more realistic is the view of the town planners. They believe that public transport, particularly suburban electric train services, are essential in a large metropolitan area. They say that a single railway line can carry 40,000 to 60,000 passengers per hour, against 2200 to 2500 per hour per lane on a freeway. If all the people who have business in a great city travel by road the roads will have to be very extensive; more important still will be car

Fig. 6 (left)—A suburban shopping centre in San Francisco. The entire space between the shops is for pedestrians; large car parks are behind the shops to the right. Fig. 7 (right)—Some of the cars parked near the Lake-Shore drive—Chicago

parks, which, even if multi-storey, will require a vast area. If the road and car park demands of a community, all travelling by private car to a city of the American multi-storey type, are granted, there will be very little space left for the city.[17]

The town planners' solution is to persuade people to travel by private car to a parking station and then travel by rapid transit to the city. The cost of the transit will have to be low and its development is thought to be as important to the community as the building of roads. It is noteworthy that London is put forward as showing an example in satisfactory transit organisation.[17] It is for these reasons that the great American city of Chicago is carrying out complete surveys of all systems of transport rather than origin-and-destination surveys of vehicular traffic alone.[18]

Parking

The parking of private cars is a major highway problem in many cities (Fig. 7). The way Chicago is tackling this problem was discussed with officials of the City Department of Public Works. A survey of parking facilities in the central business district was carried out in 1947–49 at a cost of 60,000 dollars. The following is a summary of the facts obtained :[18]

(1) Population of metropolitan area of Chicago (1950)	5,500,000
(2) Motor vehicle registrations (1950)	786,084
(3) Vehicles entering central business districts during typical twelve-hour day (1947–49 Survey)	161,232
(4) Vehicles parked legally and illegally at afternoon peak in central business district	20,750
(5) Parking space deficiency	5,850
(6) Estimated parking space deficiency by 1955	13,000

In 1952 the Chicago City Council authorised the issue of revenue bonds for 14,800,000 dollars to finance ten multi-storey parking garages in the central business district. The total capacity of these garages is 6643 vehicles. Work started on these projects in 1953 and facility No. 8 was inspected just after its opening in October, 1954 (Fig. 8). It is a hoist type of garage built on a plot roughly 80ft by 170ft. Part of the ground floor is used to hold cars in the peak period. The garage consists of three stacks of parking spaces twelve stories high ; each stack is arranged like parallel sets of pigeon-holes, there being sixteen spaces from end to end. In between the stacks No. 2 and 3 are four car lifts (Fig. 9), each lift hanging from rails at roof level. A vehicle driven into the lift at the bottom can be raised to any floor level, and during this process the lift can move horizontally until it is against a vacant stall. One lift can handle forty to fifty vehicles per hour. The total capacity of this garage is 495 cars. When seen, this garage had a turnover of 800 to 900 vehicles a day, the average income per car being 90 cents. In addition to the facilities provided by the city authorities, the Chicago Park District has built a two-level underground garage to hold 2359 cars. This garage is built under Michigan Avenue and Grant Park ; it is 1200ft long with an average width of 375ft. It was started in January, 1953, and completed by September, 1954. When visited, Grant Park, which had been removed to construct the garage, was being replaced.

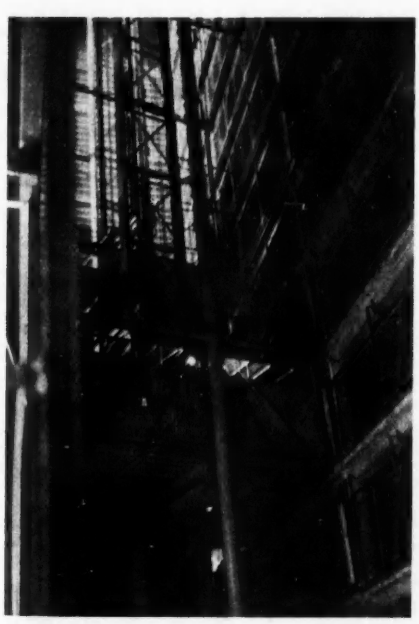

Fig. 9—A view inside the garage shown in Fig. 8. Two of the mechanical car-hoists for parking cars in the " pigeon holes " can be seen

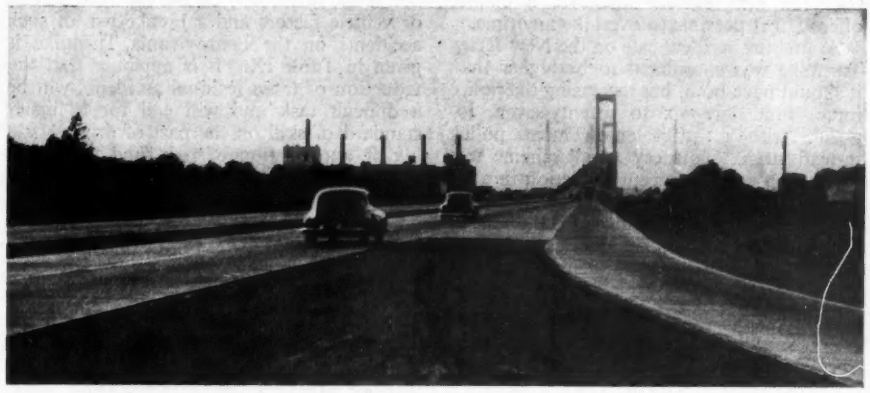

Fig. 10—The New Jersey Turnpike. The approach to the Delaware Memorial Bridge at the southern end of the road

Numerous parking lots in other parts of the city have been, or are being, built, some of them being connected by shuttle bus to the city centre. In the city itself underground garages, mechanical lift garages and ramp-type garages are being built, either by the city or the Park District authorities, at a total cost of 26,214,000 dollars. These garages will provide space for 10,428 vehicles; the average cost per space being, therefore, 2514 dollars. All the projects are expected to be finished by the end of 1955 ; it is interesting to note the comparatively short time from the talking stage of these projects to their completion.

Parking meters, although not accepted everywhere, are very widely used and the number is increasing ; over 1,000,000 are said to be in use. The point was stressed, however, that parking meters should not be used unless there are sufficient police to supervise their proper use and they should only be used where the demand for parking greatly exceeds parking space. Vigorous action has been urged to deter municipalities from using parking meters purely as a source of revenue.

Toll Roads

There is much debate in the United States about the building of toll roads. Toll roads have never been built in California but they are common in the eastern States and there are toll bridges in all parts of the country. There is considerable opposition to toll roads and bridges. For example, the American Automobile Association maintains that the requirements of highway transport " can best be met through the development of public highways, financed by taxation rather than by construction of toll roads," but in its policy statement of January, 1954, the Association is prepared to accept toll roads subject to certain safeguards.[19] The average American, although he naturally does not like paying tolls, is prepared to pay a toll if this is the only way he can get the kind of highway he wants, that is, a highway with no steep grades, no cross traffic, no traffic congestion, no sharp curves, and where steady speeds of 50 to 60 m.p.h. can be maintained with ease.

The operation of the New Jersey Turnpike (Fig. 10), a toll road from New York to the Delaware River was discussed with the chief engineer and his chief traffic engineer. This turnpike was financed by private investors who purchased bonds carrying a fixed tax-free interest which are to be repaid over a number of years. At the end of this period the turnpike becomes the property of the New Jersey State. The Authority has three unpaid Commissioners who have considerable authority, including power of compulsory purchase of land. The Authority originally borrowed 220,000,000 dollars but later had to ask for a further 60,000,000 dollars. The total income from tolls and concessions is now (1954) about 21,000,000 dollars ; maintenance and administration cost about 5,000,000 dollars.

The Authority owns a strip of land 250ft wide for the 118 miles of the turnpike. The firm of consultants employed to estimate traffic flow were very conservative in their traffic estimates, the present flow of 20,000,000 vehicles per year is two and a half times that of the original estimate ; 60 per cent of the traffic is new or " induced traffic." The existence of the road has improved land values and done much to improve the prosperity of the adjacent districts. The headquarters of the Authority at New Brunswick are the nerve centre for this thriving business enterprise. Here are found the engineering, maintenance and design staff, the mechanised accounting system, the accident records, and the radio transmitter linking the toll booths and the police patrols. Roughly every 12 miles along the road there are service areas with car parks, restaurants, snack bars, and service stations operated by concessionaires. Motorists are forbidden to stop on the road or the shoulders, but are encouraged to use these service areas for relaxation or repairs. This is because stationary vehicles on the side of the road have been in the past frequently associated with accidents, particularly at night. The authorities are of the opinion that some special light indication is necessary for any vehicles which have inadvertently stopped at night as this is proving a serious hazard. An interesting feature of travel on a turnpike is the absence of very slow or very fast vehicles. There is apparently little urge to rush ahead and over-

take the next vehicle whenever a chance offers ; it is possible to overtake any time.

At first the accident rate on the New Jersey Turnpike was considered to be higher than it should have been, but increasing the police force from thirty-six to seventy-seven, together with a strict enforcement policy instead of a "courtesy cop" scheme was followed by a 20 per cent reduction in accidents during a time when traffic had risen by 20 per cent. Through the kindness of Dr. J. W. Forbes, of the American Institute of Research, the latest accident analysis of the 327-mile Pennsylvania Turnpike[20] was obtained and comparative accident rates are given in Table VII. They have been compared with the British data for 1949 for roads in Bucks obtained by the Road Research Laboratory.[21]

TABLE VII—*Accident Rates on Two Toll Roads*

Class of accident	Motor vehicle accident rate per million vehicle miles		
	New Jersey Turnpike	Pennsylvania Turnpike	Trunk and class I roads in Bucks in non-built-up areas*
Fatal	0·036	0·07	0·08
Personal injury	0·62†	0·53	2·4
Damage		0·89	Unknown

* Excluding cyclists.
† Excluding damage value under 100 dollars.

These American toll roads, built for motor and not horse-drawn traffic, are saving life and limb as well as time.

The detailed keeping of accident records on a toll road enables comprehensive analyses to be undertaken of the factors associated with accidents. One such breakdown is shown in Table VIII, which gives accident rates on the Pennsylvania Turnpike in 1952 and 1953 grouped according to road, weather and light conditions. It may be assumed that, in these motorways, most of the accidents which might be associated with poor road design have been eliminated. There remains, however, a "hard core" of accidents, which may be attributed to human or vehicle factors and a breakdown of such accidents on the Pennsylvania Turnpike is given in Table IX. It is apparent that the reduction of these residual accidents will be a difficult task and will call for a higher standard of skill on the part of drivers or a higher appreciation of risk, and up to the present no one has any easy panacea.

TABLE VIII—*Accident Rates for Various Road and Light Conditions on the Pennsylvania Turnpike During the Years* 1952–53 *(all Accidents)*

Condition	Accidents per million vehicle miles
Type of road :	
Straight*	1·5
Curved†	1·5
State of road :	
Dry	1·1
Wet	1·9
Snow, slush	4·8
Icy	8·2
Weather :	
Clear or cloudy	1·2
Fog	1·3
Precipitation	2·5
Light conditions :	
Day	1·5
Night, dusk or dawn	1·5

* Including curvatures up to 30ft per 100ft of road.
† The maximum curve radius of the turnpike is 6 deg., and maximum grade is 3 per cent.

TABLE IX—*Human and Vehicle Factors Associated with Accidents During* 1952 *and* 1953 *on the Pennsylvania Turnpike*

Driver or vehicle factor associated with accident	Percentage of all accidents in which this was primary factor (per cent)
Failure to cope with road conditions (mostly skidding accidents on slush, snow or ice)	22
Illegal or unsafe action	21·5
Inattentiveness (driver asleep, 13·2 per cent ; attending to other tasks, 4 per cent)	17·2
Vehicle failures (blowouts, brakes, fire, structural failure, &c.)	13·8
Deficiency in routine driving skill	11·7
Misperception—or failure of judgment	8·2
Failure to avoid miscellaneous objects on road (deer, rocks, dogs, &c.)	3·7
Miscellaneous	1·9
Total	100

(To be continued)

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American Nuclear Power Reactor Programme

Economic aspects of the American nuclear power reactor programme were discussed in a paper, "Economics of Nuclear Power," presented by Mr. J. A. Lane (Oak Ridge National Laboratory) to the recent International Conference on the Peaceful Uses of Atomic Energy at Geneva. In the following abstracts from the paper we outline the principles of some of the more promising reactor systems and give the author's conclusions on the outlook for low cost nuclear power.

IN 1975, the production of electricity in the United States will amount to 1400 billion ($1{\cdot}4\times10^{12}$) kwh according to estimates made by the Paley Commission and others.[1,2] Most of this electricity will be supplied by burning coal, oil and gas ; a smaller portion from nuclear plants. Just what this portion will be depends on how successful the present reactor development programme is in solving the many technical problems which affect nuclear power economics. At this time, one can only define what these problems are, what is being done to solve them, and what the outlook is if these solutions are successful. Since the above estimate of the increase in the electric power system over the next twenty years constitutes a potential nuclear plant investment of about 30,000 million dollars, the rewards for a successful reactor development programme may be great. The technical achievements of the U.S. reactor programme thus far realised, give added incentive for pushing ahead with the development of civilian power reactors at maximum speed.

Two approaches to the development of large-scale power reactor technology are under way in the United States. They are (*a*) the A.E.C. five-year civilian power reactor programme ; and (*b*) industrial power demonstration reactor proposals. A review of these programmes from the standpoint of their relation to the possibility of achieving economic nuclear power is worth while.

REACTOR DEVELOPMENT PROGRAMMES

The A.E.C. Five-Year Civilian Power Reactor Programme.—This programme, announced last year by the Atomic Energy Commission, involves the construction of one full-scale pressurised water reactor power plant and intermediate or small-scale prototypes of other reactor types which show promise of achieving low cost nuclear power. These are listed in Table I. It will be noted that approximately 200 million dollars will be required to support this programme over the next five years with the objective of providing actual construction and operating experience with these reactor systems. The building of these prototype power plants will not only provide information leading to reduced costs, but will also permit a more realistic evaluation of the applicability of nuclear energy for larger scale power production.

Industrial Power Demonstration Reactor Proposals.—A more venturesome reactor programme involving the construction of full-scale nuclear plants is being considered by various industrial groups in the United States. These are listed in Table II. Except for the Consolidated Edison reactor, which would be built entirely with private funds, the proposals involve some help from the government. This help includes the waiving of established A.E.C. charges for the loan of nuclear fuel and fertile material for a period of up to seven years, the support of A.E.C. laboratories in performing research and development work without charge, and the advance payment by the A.E.C. for the technical and economic information to be gained. If all of these proposals are acted upon favourably, the installed nuclear plant capacity in the United States will amount to about 800,000kW of electricity by the year 1960.

PROMISING REACTOR SYSTEMS

The A.E.C. prototype reactor programme and the industrial full-scale reactor proposals both deal with the types of reactors which studies have shown offer the most promise for competitive power. These are : (*a*) the pressurised water reactor (PWR) ; (*b*) the boiling reactor (BWR) ; (*c*) the sodium graphite reactor (SGR) ; (*d*) the fast breeder reactor (FBR) ; and (*e*) the aqueous homogeneous thorium breeder reactor (TBR). Schematic diagrams of these reactors are shown in Figs. 1 to 5.

In the pressurised water reactor (Fig. 1), a

TABLE I—*A.E.C. Five-Year Civilian Power Reactor Programme*

Reactor type	A.E.C. laboratory	Power, MW		Cost,* millions of dollars	Estimated completion
		Heat	Electricity		
Pressurised water (P.W.R.)	Westinghouse	264	60	85	1957
Boiling water (E.B.W.R.)	Argonne	20	5	17	1956
Sodium graphite (S.G.R.)	North American	20	—	10	1956
Fast breeder (E.B.R.-2)	Argonne	62·5	15	40	1958
Homogeneous reactor test (H.R.E.-2)	Oak Ridge	5	1	3	1956
Homogeneous thorium breeder (T.B.R.)	Oak Ridge	65	16	44	1959

* Includes some research and development.

TABLE II—*Industrial Power Demonstration Reactor Proposals*

Reactor type	Sponsoring group	Power, MW electricity	Cost, millions of dollars	Estimated completion
Pressurised water	Yankee Atomic Electric	100	24	1957
Boiling water	Commonwealth Edison (Nuclear Power Group)	180	45	1960
Sodium graphite	Consumers Public Power District	75	24	1959
Fast breeder	Detroit Edison	100	45	1958
Pressurised water	Consolidated Edison*	236	55	1959

* Licence requested for construction with private capital.

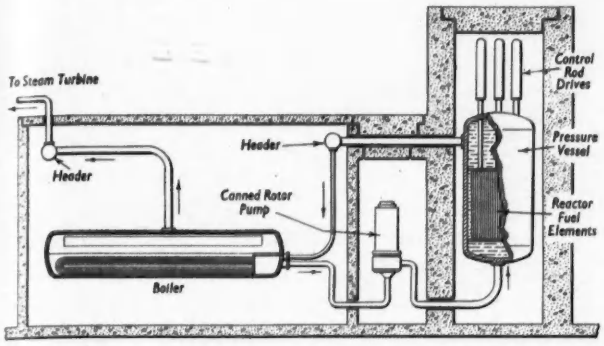

Fig. 1—Pressurised water reactor system (forced circulation H_2O or D_2O)

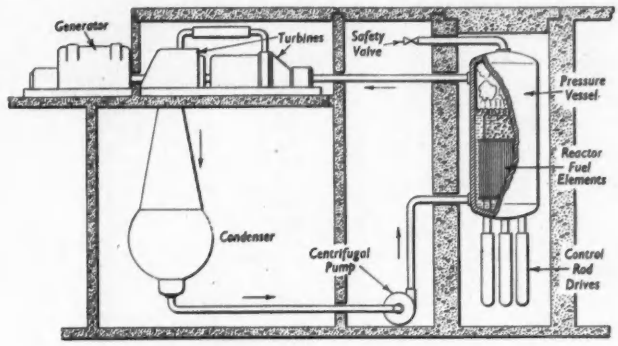

Fig. 2—Boiling water reactor system

full-scale version of which is now being constructed by Westinghouse, either heavy water or ordinary water can be used as the coolant and moderator with appropriate adjustment of the spacing and enrichment of fuel elements. (The Westinghouse reactor uses H_2O.) The water is pumped between the solid fuel rods in the reactor core and thence to a heat exchanger where steam is produced to drive a turbine.

In the boiling water reactor (Fig. 2) (also using either H_2O or D_2O), steam is produced directly by allowing boiling to occur within the reactor core. This method of heat removal eliminates the heat exchanger, has corresponding higher thermal efficiencies and reduces the size of pumps and other equipment. Off-setting these advantages are the required higher fuel enrichment due to the presence of steam in the core and the necessity for enclosing the turbine and condenser within a shield due to the radioactivity of the water.

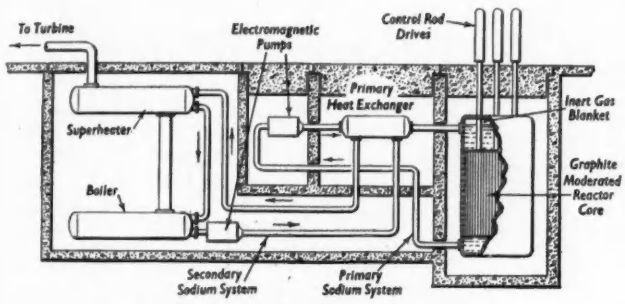

Fig. 3—Sodium graphite reactor system

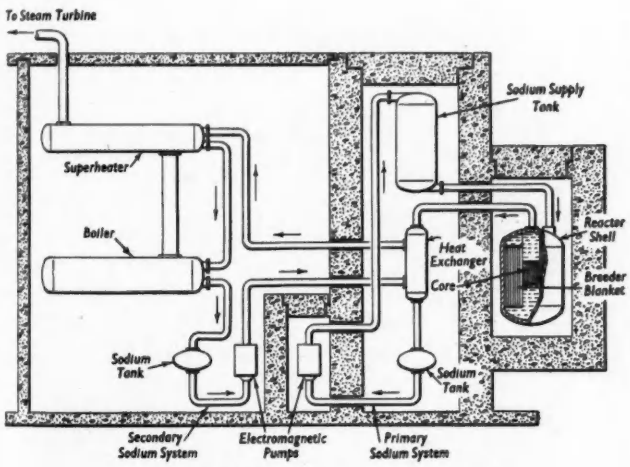

Fig. 4—Sodium cooled fast reactor system

The sodium graphite reactor (Fig. 3) takes advantage of the high temperatures and high thermal efficiencies to be gained through the use of liquid sodium as the coolant and graphite as the moderator. Here the primary sodium coolant circulates between solid fuel elements in the reactor and then through a heat exchanger where heat is transferred to a secondary sodium system. In contrast to the primary sodium, which becomes radioactive, the secondary sodium can be circulated outside the shield through a steam generator.

The use of sodium as a high-temperature coolant is also applicable in the case of a fast breeder reactor (Fig. 4). Here the reactor consists of an unmoderated core, fuelled with plutonium containing some uranium-238, and surrounded by a uranium-238 blanket. Primary sodium is used to cool both the core and blanket in conjunction with a secondary sodium system, as in the case of the SGR. The advantage of the fast breeder is the high breeding gain possible with fast neutrons in the Pu-239, U-238 system, due to the lower parasitic capture of neutrons by Pu-239 itself. On the other hand, fast reactors require a large amount of nuclear fuel to achieve criticality with corresponding high inventory charges.

Finally, the aqueous homogeneous reactor (Fig. 5) uses a dilute solution of U-233 in D_2O flowing through an inner core vessel, in which the major portion of the heat is generated. This core is surrounded by a larger pressure vessel through which a suspension of ThO_2 in DO_2 is circulated, the thorium serving as a breeding blanket. Both the core solution and blanket suspension are circulated through heat exchangers where steam is generated. The advantage of using a fluid fuel and blanket is primarily that of having simpler chemical processing systems and thus lower fuel processing costs. Both the uranium solutions and thorium suspensions, however, are somewhat corrosive, highly radioactive, and in general require very special fuel-circulating and heat-removal systems. One of the major problems in handling aqueous fuel solutions is caused by the decomposition of D_2O in the presence of radiation. The explosive deuterium-oxygen gas mixture thus formed must be separated from the circulating liquid stream, as shown in Fig. 5, and recombined before being injected back into the system. The pressurisers shown serve to maintain a constant volume and prevent boiling in the circulating liquid.

The Nuclear Plant Steam System (Turbo-Generator Plant).—Most of the emphasis of the reactor experimental programme thus far has been associated with the problem of finding reactor systems capable of operating for long periods at the high temperatures necessary for efficient power production. The most promising approaches use sodium at temperatures of 900 deg. to 1100 deg. Fah. (480 deg. to 600 deg. Cent.) and pressures of about 100 lb per square inch absolute, or water at 540 deg. to 630 deg. Fah. (270 deg. to 320 deg. Cent.) under pressures up to 2000 lb per square inch absolute. The resulting steam temperatures shown in Fig. 6 range from 400 deg. to 1000 deg. Fah. Although such a range of temperatures has a considerable effect on the net thermal efficiency of the power recovery plant, also shown in Fig. 6, the corresponding capital costs of this portion of the nuclear plant do not vary as widely. In the case of the water-cooled reactors, turbo-generator plant costs are seen to vary from 115 dollars per kilowatt to 125 dollars per kilowatt, and for the sodium-cooled reactors from 97 dollars per kilowatt to 100 dollars per kilowatt. The significance of this aspect of nuclear power economics is that differences in power costs in various types of nuclear plants and in conventional plants will be due primarily to the construction costs and operating costs of the boiler plant, or reactor, rather than to the turbo-generator plant. For power cost comparison purposes, therefore, it is usually sufficient to merely assume that the turbo-generator plant costs will correspond to the costs shown on Fig. 6, according to the temperature of the steam in the nuclear plant being considered.

Review of Estimated Capital Costs

Data on the cost of electricity from large-scale nuclear plants now available are all based on paper studies. At the best, they represent the considered judgment of those most familiar with the various technical and economic factors involved. It can be shown[3, 4] that in most cases the estimated power costs are more strongly affected by the various non-technical assumptions employed, such as plant write-off, inventory charges and load factor, rather than by factors related to reactor technology. Estimated capital costs of various large-scale nuclear power plants taken from the literature[5, 6] vary from 183 dollars per kilowatt capability to 450 dollars per kilowatt. (It should be noted that some of these costs represent firm bids for actual projected plants.) Corresponding power cost estimates range from 4 mills per kilowatt-hour* to 10 mills per kilowatt-hour, as will be shown later.

Specifications for Competitive Nuclear Power

Members of the staff of the A.E.C. have estimated the amounts of energy from steam generating capacity required in 1975 as a function of the cost of power.[7] On this basis the potential market up to 1975 for nuclear plants which produce power at 10 mills per kilowatt-hour is 300 million dollars. This potential increases to 3800 million dollars at costs below 7 mills per kilowatt-hour and 25,000 million dollars at 4 mills per kilowatt-hour. Thus it is important to determine what conditions must be met for nuclear plants to achieve power costs in these ranges. The main problem here is not one of determining how much the nuclear plant will cost, but in estimating (*a*) how long it will last,

* 1 mill = 0·001 dollars.

(*b*) the operating and maintenance costs, and (*c*) the net fuel cost after adding charges due to fuel inventories, fuel burn-up and fuel reprocessing, and subtracting the value of new fissionable material in the reactor. Since there is no actual operating experience with large-scale nuclear power reactors available at the present time, most nuclear power cost estimates are greatly affected by the degree of optimism used in selecting the reactor amortisation period, the load factor and the operating and maintenance costs. This is evident in the following paragraphs which define the conditions and assumptions necessary to obtain power costs at 4 mills per kilowatt-hour, 7 mills per kilowatt-hour, and 10 mills per kilowatt-hour respectively.

4-*Mill Power Costs.*—To obtain power costs of 4 mills per kilowatt-hour in nuclear plants it will be necessary to achieve very favourable operating conditions such as a 90 per cent load factor and maintenance costs as low as 0·5 mills per kilowatt-hour. Under these conditions, at the lowest estimated nuclear plant costs of 180 dollars per kilowatt capability, net fuel costs as defined above of 0·10 mill per kilowatt-hour must be realised.

7-*Mill Power Costs.*—At average capital costs and less optimistic operating conditions (i.e. 80 per cent load factor and 1·0 mill per kilowatt-hour operating and maintenance costs) nuclear power costs in the range of 7 mills per kilowatt-hour will be reached with net fuel costs between 0·5 and 1·2 mills per kilowatt-hour.

10-*Mill Power Costs.*—Nuclear power costs of 10 mills per kilowatt-hour can be projected on the basis of a relatively conservative set of operating conditions, such as a 70 per cent load factor and maintenance costs up to 1·2 mills per kilowatt-hour. At estimated capital costs of 290 dollars per kilowatt, net fuel costs of 1·7 mill per kilowatt-hour would be sufficient. A more complete breakdown of estimated capital costs and the required net fuel costs to achieve economic power in water-cooled reactors (PWR, BWR and TBR) and sodium-cooled reactors (SGR and FBR), respectively, is shown in Table III. It will be later shown just how realistic these net fuel costs are.

TABLE III—*Required Net Fuel Costs for Competitive Nuclear Power*

	Dollars/kW	Mills/kWh	Dollars/kW	Mills/kW	Dollars/kW	Mills/kWh
1—Water Cooled Reactors :						
Boiler plant (reactor)	60	1·1	95	2·0	130	3·2
Turbo-generator plant	120	2·3	130	2·8	150	3·7
Operation and maintenance	—	0·5	—	1·0	—	1·2
Required net fuel costs (inventory + processing costs — by-product credits)	—	0·10	—	1·2	—	1·9
Total	—	4·0	—	7·0	—	10·0
2—Sodium Cooled Reactors :						
Boiler plant (reactor)	130	2·5	155	3·3	180	4·4
Turbo-generator plant	100	1·9	105	2·2	110	2·7
Operation and maintenance	—	0·5	—	1·0	—	1·2
Required net fuel costs (inventory + processing costs — by-product credits)	—	−0·9	—	0·5	—	1·7
Total	—	4·0	—	7·0	—	10·0

Nuclear Fuel Systems

Although enriched uranium-235 has a very high energy content (20×10^6 kWh of heat per kilogramme), in the estimated price range of 15 dollars to 30 dollars per gramme, it is a no cheaper fuel than coal. Since the most attractive aspect of nuclear energy is the possibility of achieving fuel costs considerably below that for coal, all nuclear fuel systems being considered for large-scale power production involve breeding or regenerative systems. Here uranium–238 or thorium–232 is placed in the reactor core or around the core as a blanket, whereby through the capture of neutrons new nuclear fuel is produced. The extent of the capture depends on how well the fertile uranium or thorium competes with the other materials in the reactor system after allowing for losses due to neutron leakage. The continual striving for higher neutron economy—that is, more efficient neutron absorption in fertile material—represents the major portion of that part of the civilian reactor development programme aimed at economic power. This programme includes the development of the technology of low neutron absorbing structural materials such as zirconium, the use of special moderating materials, such as D_2O, and the consideration of the special problems associated with fast reactors. These aspects of the U.S. reactor programme will be covered in other papers. In so far as economic factors are concerned, it is necessary only to consider neutron economy in a general way, such as that measured by the conversion ratio of the system. This is usually defined as the atoms of new fuel produced in fertile material per atom of fuel burned. Depending on the particular reactor design, the conversion ratio may vary over a wide range. However, for the particular types of reactors being considered, the maximum conversion ratio will be of the order of 1·0 for the regenerative reactors (PWR, BWR and SGRO), about 1·2 for the aqueous thorium breeder (TBR), and about 1·6 for the fast breeder (FBR).

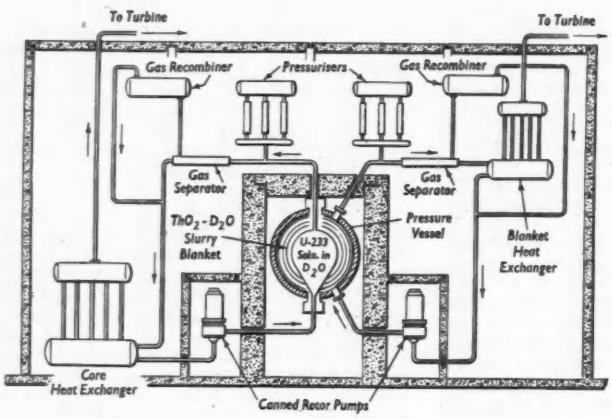

Fig. 5—Aqueous homogeneous thorium breeder reactor system

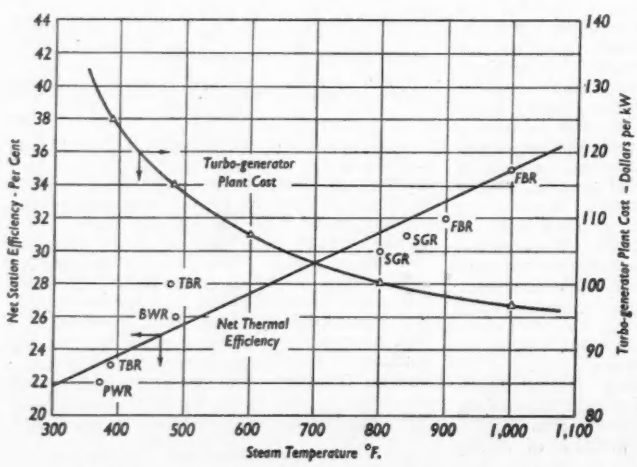

Fig. 6—Characteristics of nuclear steam-turbo-generator plants

Fuel Costs in Regenerative Reactors

The regenerative reactors, which use natural or slightly enriched uranium, are closely tied to an isotope separation plant, such as the gaseous diffusion plant. This serves to provide slightly enriched uranium as feed to the reactor (if necessary) and to re-enrich the depleted fuel. The fuel costs in these reactors depend essentially on the cost of slightly enriched uranium, the irradiation time, the value of depleted uranium as feed to the isotope plant, the various chemical processing and fabrication costs, and, finally, the value of plutonium in the depleted fuel.

Outlook for Low-Cost Nuclear Power

On the basis of a cost of natural uranium of 40 dollars per kilogramme and a credit of from 15 dollars to 30 dollars per gramme of fissionable material produced in the reactor, the possibility of achieving nuclear power costs in the neighbourhood of 4 to 5 mills per kilowatt-hour seems good. This can be done in a pressurised water reactor plant fuelled with natural uranium and cooled and moderated with heavy water. Such a plant would have to cost no more than 200 dollars per kilowatt capability, excluding the cost of D_2O. The plant would have to operate at a 90 per cent load factor, assuming 15 per cent annual fixed charges on plant and 4 per cent on fuel inventories. An irradiation time of fuel elements of from 5000 MWD/T to 6000 MWD/T is required.

Power costs at 5 mills or less might also be achieved in an ordinary water-cooled and moderated reactor fuelled with 1 per cent U-235. With plant costs similar to those given above, irradiation times of the order of 10,000 MWD/T would be required in this case.

With regard to the breeder reactors, power costs of 4 to 5 mills per kilowatt-hour are possible at fuel processing costs of 1 dollar per gramme or less. Under these conditions the cost of a power plant utilising a fast breeder with a conversion ratio of 1·6 could be as high as 270 dollars per kilowatt with a 90 per cent load factor. With similar processing costs and a conversion ratio of 1·15, an aqueous homogeneous nuclear power plant would have to cost 200 dollars or less per kilowatt capability to produce power at less than 5 mills per kilowatt-hour.

With regard to the sodium-cooled graphite-moderated regenerative reactor no reasonable combination of fuel costs and published capital costs can be now projected which yields electrical power below 5 mills per kilowatt-hour. However, the possibility of getting into the 6–7 mills per kilowatt-hour range seems very good with this system. Here the required conditions would be reached in a plant costing 240 dollars per kilowatt capability, fueled with 2 per cent enriched uranium at irradiation times of 10,000 MWD/T.

Taking all available economic and technical information at its face value, it is evident that the outlook for large-scale nuclear power in the United States is very promising. If anticipated nuclear plant costs and operating conditions, such as long life of equipment, high load factor and efficient fuel utilisation, moreover, can be realised, such plants will produce electricity at prices well below the average for conventional fuels. There is good indication that these necessary advances will be achieved in the next five to ten years through the vigorous reactor development and nuclear power plant construction programme now under way.

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Arc-Welding Plant and Electrodes Supply Organisation

IN the course of a recent press visit to the works of the Quasi-Arc Company, Ltd., Bilston, and Fusarc, Ltd., Gateshead, it was announced that, as from October 1st next, the interests and activities of the two concerns would be combined under a new organisation, to be known as Quasi-Arc, Ltd., with head offices at Bilston, Staffs. The new organisation will provide within one concern complete technical co-operation for plant and electrode research and development, as well as simplifying the marketing of equipment and materials made by the firms and covering the whole field of manual and automatic arc welding.

Fusarc, Ltd., has for many years specialised in the manufacture of automatic arc welding plant, and in the tour of the Gateshead works a number of special machines as well as the firm's standard products were shown in course of construction. The continuous electrode automatic welding head has been adapted for a wide field of application both as a stationary and a self-propelled machine. In a plant demonstrated, one of these heads was operating in conjunction with "Unionmelt" equipment and building up worn parts with a heavy deposit of metal. This "Unionmelt" automatic welding process, which deposits weld metal from a continuous wire with a finely divided powder surrounding the arc to protect the molten weld metal, is being increasingly used where fast deposition with deep penetration is required.

More recent introductions to the plant made by the firm are "Sigma" or inert-gas, shielded-arc welding equipment using Argon gas, and "Heliarc" equipment. A development of the "Twin Arc" hand welding process, where twin electrodes are used to produce fast welding with better balance on electric power mains, is an automatic, continuous welding machine. On this machine wire is fed from two coils simultaneously, one depositing at the root of the weld and followed by the second wire completing the deposit in the same pass.

In addition to automatic welding equipment the works also manufactures in a large fabricating shop a variety of mechanical manipulating plant. The plant made includes positioners, roller beds for cylindrical work, structures such as cantilever carriages for carrying adjustable overhead welding equipment, boom supports for internal welding heads, portal frames for gantry supported heads and mobile engine-driven generator equipments.

Under the new organisation this Gateshead works will become the engineering factory of Quasi-Arc, Ltd., and it will be responsible for the manufacture of all automatic welding equipment, including the welding heads, power packs and mechanical manipulative equipment for both automatic and hand welding, as well as the manufacture of petrol and diesel engine-driven sets for manual arc welding.

The Quasi-Arc factory at Bilston makes a variety of equipment for manual arc welding, but a majority of its capacity is devoted to the manufacture of electrodes, of which no less than forty different kinds are made in about 250 types and sizes. It is estimated that the annual electrode production of the works is well in excess of 300 million feet, and to manufacture this vast quantity of electrodes a number of special machines have been developed and built by the firm. On new high-speed machines installed some two years ago, the wire is drawn directly from coils, straightened, cut and covered with extruded paste. From the machines the electrodes are taken by conveyors to subsequent sections of the installation, where they are dried, counted and packed in one continuous line, to give a production speed of up to 1000ft a minute. In addition to the production of manual welding electrodes, "Fusarc" continuous coil electrodes are also manufactured at Bilston on machines of the company's own design, and by a process ensuring a product of the constant quality which is essential for the high-speed, high-current automatic welding operations in which the electrode is used.

Well-equipped laboratories of the research and development section of the factory are responsible for the quality control of electrodes during production, and all materials before release to the manufacturing departments have first to receive laboratory approval. An important function of this laboratory is the development of new electrodes, new welding processes and the continued improvement of existing products and processes. Its equipment includes a complete pilot plant for the production of small quantities of newly-developed electrodes. Separate chemical, mechanical and physical testing laboratories have facilities for metallographic, spectrographic and X-ray diffraction work and there is a complete X-ray installation.

Heavy duty, hydraulically operated road grader

Heavy Duty Road Grader

THE road grader shown in operation in our illustration is now being manufactured and distributed by the Distington Engineering Co., Ltd., Workington, Cumberland. This machine is known as the "Distington B.80 Mark 3," and whilst it has been made for some time by the company it has been marketed through independent channels.

It is a hydraulically operated machine powered by a Leyland diesel engine developing 75 h.p. at 1650 r.p.m. and 80 h.p. at 1800 r.p.m. Power from the engine is transmitted through a single-plate clutch, a two-speed transfer box and a four-speed gearbox to the fully floating rear axles. With the engine running at 1650 r.p.m. the grader has eight forward speeds from 2·42 to 20·43 m.p.h. and two reverse speeds of 3·42 and 4·68 m.p.h. The front axle is pivoted centrally and the wheels can be tilted hydraulically to counter heavy side thrust such as when using the machine on bank cutting. Power assisted steering is fitted to reduce manual effort on the part of the driver to a minimum. The grader has a heavy box section frame fabricated from rolled steel channels and steel plate, with a heat treated carbon steel circle in which the gear teeth are machined.

The circle is 60in diameter and is hydraulically driven through worm reduction gearing. A 12ft long, 22½in deep mouldboard can be fitted with 2ft extensions, and two 6ft long blades are used. The hydraulically operated blades have a maximum lift of 19in above ground level and a side shift of 112in from the centre line of the machine with the blade centrally mounted. Six blade tilting positions are available and the maximum bank cutting angle for which the blade can be set is 90 deg. A hydraulically operated scarifier has eleven teeth and its swathe width is 46in.

Without the scarifier (which weighs 1350 lb) the grader weighs 21,770 lb, of which 6700 lb is on the two front wheels and 15,070 lb on the four rear wheels. The maximum pressure which can be exerted on the blade is 13,900 lb and on the scarifier 8960 lb.

Plate Pickling Plant

PARTICULARS have been received from the Kestner Evaporator and Engineering Company, Ltd., 5, Grosvenor Gardens, London, S.W.1, of a large plant supplied to the Motherwell Bridge and Engineering Company, Ltd., for the acid pickling and phosphating of steel plates, sections, &c. The three process tanks of the installation each have internal dimensions of 35ft long by 7ft wide and 9ft 6in deep, and they are of mild steel, rubber and brick-lined construction.

In the pickle tank in which the work is first immersed, the sulphuric acid is heated by submerged combustion equipment. After pickling the work is transferred to an adjoining warm water wash tank and then to the phosphating tank for immersion in hot dilute phosphoric acid. The acid of the phosphating tank is heated by an external shell and tube heat exchanger supplied with steam by an automatic boiler. Condensate from the heat exchanger is used to heat the water in the wash tank.

In order to economise in sulphuric acid and to reduce the problem of effluent disposal, the plant incorporates a "Kestner-Fakler" acid recovery equipment giving copperas as the by-product. The slightly acidic wash water is passed through an automatically controlled neutraliser, using lime as the neutralising agent, before it is delivered into the local drainage system.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE CROSTI AND FRANCO-CROSTI BOILER

SIR,—As the representative of the S.A. Locomotive a Vapore Franco who was responsible for drawing the attention of British engineers to the Crosti boiler, I was most interested in your editorial of August 12th on the new British Railways Crosti locomotives. I regret that absence abroad has prevented me from addressing you sooner on the subject for there are various considerations I should like to place before you.

It is respectfully suggested that your historical approach to the Crosti boiler as the latest in a long line of feedwater heating devices—which are commonly regarded as pieces of apparatus to add to existing boilers as required—has led you astray in your evaluation and caused you to compare items that are not strictly comparable, e.g. the heating surfaces of a normal boiler and a Crosti main boiler designed for similar steam productions. The claim is put forward that the Crosti boiler is an attempt to advance on the "Stephenson" boiler which, with the single major improvement of Schmidt's superheater, has now served the steam locomotive for 125 years. Assuming this claim to be justified, and some considerations in support are given below, it is apparent that it should be distinguished from the feed heater as generally known.

The Crosti boiler is an integral whole, each part of which, firebox, main boiler, front smokebox, preheater and final smokebox is essential to the correct functioning of the whole and each part of which is designed in relation to the others; remove any one part and the remainder is useless. There is the old difficulty, for example, of drawing gases through long boiler tubes without excessive rise in back pressure on the pistons. Various features of the Crosti boiler hold down back pressure, among them the dropping of the A/S ratio of the main boiler to 1/380 or so while maintaining that of the preheater at the more or less normal 1/400. Thus the tubes and flues of the main boiler offer less resistance to gas flow as their diameter is large compared with their length, but a reduction in heating surface follows from this.

Less coal is burnt in the Crosti boiler for a given steam production—demonstrated by 138 existing boilers in Italy and Germany and shortly to be demonstrated by British Railways—and the rate of combustion for a given grate is less than that of a "Stephenson" boiler of the same capacity. The amount of flue gases is reduced and hence it is permissible to reduce the free gas area through both the main boiler and preheater, which facilitates design as smaller diameter barrels can be employed, particularly important where there are loading gauge or weight restrictions. But once again the main boiler heating surface is reduced.

As you have said the temperature of the flue gases in the front smokebox after passing through the Crosti main boiler is higher than would be desirable in a normal smokebox, but after the gases have passed through the preheater to the final smokebox the comparable temperature is very much lower. Typical figures quoted in Italy are 392 deg. Fah. at the chimney of the Crosti boiler against 662 deg. Fah. at the "Stephenson" boiler chimney. Within limits it is immaterial where heat is extracted from the products of combustion, either in the main boiler or the preheater, as long as this heat is transferred to the boiler water. The aim is so to proportion the Crosti boiler as a whole that water passes from the preheater to the main boiler at just below working pressure vaporisation point. In fact, Dott. Ing. Crosti has suggested that it would be less confusing if the description "main boiler" were dropped and the term "vaporiser" substituted.

It is hoped that sufficient has been said to support the claim that the Crosti boiler is a true boiler. Your observation that the British Railways Crosti locomotive appears to be deficient in heating surface in the main boiler is valid supposing it was intended to function separately as a "Stephenson" boiler, but as has been shown this was never intended. As a corollary your desire to see a preheater fitted to an existing boiler design would be difficult if not impossible to carry out as it would be difficult to ensure the proper proportions. If it could be done the result would be a larger boiler all round, i.e. more steam for a given coal consumption, but even so it would then appear desirable to enlarge the grate area to give reasonable combustion rates.

Finally it will be observed that I have referred throughout to the Crosti boiler. In Italy there are two types of boilers in service, one with two preheater drums flanking either side of the main boiler, termed the Franco-Crosti boiler, and one with a single preheater as on the British Railways locomotives, termed the Crosti boiler. The distinction appears to be useful and worthy of perpetuation.

P. M. BISHOP

London, N.W.11.
September 4th.

Literature

A History of Mechanical Inventions. By ABBOTT PAYSON USHER. Harvard University Press, Cambridge, Massachusetts. Revised Edition 1954. Distributed in Great Britain by Geoffrey Cumberlege, Oxford University Press. Price 72s.

THE author, who is Professor Emeritus of Economics at Harvard University, has enlarged the first edition, published in 1929, by substituting four new chapters for the first two and revising nine; three chapters are practically unchanged. The new volume is not confined to mechanical inventions but is a broad study of the history of technology from antiquity to the present day. To compress so much history into one volume of 450 pages is a formidable task and Professor Usher and the publishers have produced an attractive and interesting book. It will eventually be eclipsed by *A History of Technology*, planned in five volumes and edited by Singer, Holmyard and Hall, of which Volume I with 830 pages has already been published by the Oxford University Press.

In the first four chapters, which are of special interest to students of economic and social history, Professor Usher deals with the place of technology in economic history, the historical analysis of social change, the particular system of events and the emergence of novelty in thought and action, quoting many examples from primary crafts. He develops the theory of invention based on *Gestalt* psychology (the German word meaning form or shape) a term introduced by Ehrenfels in 1890 to indicate the character of a perception as a unity. According to Köhler and others of the *Gestalt* school, we deal mentally with whole objects of particular shape, size and position, rather than with elements. These early chapters, parts of which reach "the higher levels of abstract thought," may appear too abstract to engineers unfamiliar with psychology and the author's numerous concepts, an overworked word used fifteen times on page 43, fourteen times on page 45 and so on. The middle chapters are easier to grasp as they deal with the early history of pure and applied mechanical sciences, the mechanical equipment of pre-Christian antiquity, the development of water-wheels, windmills and clocks (water and mechanical) up to A.D. 1500. Two chapters are devoted to Leonardo da Vinci, engineer and inventor, and to the invention of printing respectively. The later chapters cover the development of textile machinery and of clocks and watches up to 1800; machine tools and quantity production from 1450 to 1850; and the production, application and distribution of power from 1500 to the present day.

This volume, the first to be published by the Harvard University Press in which photographic type setting has been used, contains 159 illustrations, mostly line drawings. Some indication should have been given whether they were actual copies of originals or drawn specially for the author; for example, Fig. 38, representing the dioptra of Hero, looks far too modern. The eleven half-tone illustrations would have been better printed on art paper as their standard of reproduction is inferior to the first edition and is not good enough for a volume selling at this price. The fourteen pages of references and ten pages of bibliography are most useful but the index is barely adequate; certain subjects, e.g. early Chinese technology, metals, are difficult to find.

In reviewing the first edition in our issue of March 7th, 1930, page 275, we wrote that the reader was entitled to a higher degree of accuracy and many statements in the volume should be accepted with caution. Of the mistakes mentioned, only about half have been corrected, and several more have been introduced. If the proofs of the revised edition had been checked by an engineering historian or librarian in England, a number of mistakes could have been avoided. We are surprised to read on page 372 that "Naysmith made signal improvements in the design and control of the steam hammer." The facts are that James Nasmyth invented the steam hammer and his first drawing of it was dated November 24, 1839. On page eight Professor Usher rightly says that, as railroad networks developed in North America and in Europe,

life was profoundly transformed ; it is therefore remarkable that he compresses the history of the steam locomotive, surely one of the most important achievements in mechanical engineering, into two paragraphs on page 357. The invention of the U-shaped boiler flue and the introduction of exhaust steam into the chimney were due to Trevithick, not Hackworth. The famous Rainhill locomotive trials were held in October 1829, not 1830. The statement that in 1784 Murdock made " a successful model of a high pressure locomotive engine " is misleading unless it is further explained that the diminutive model (preserved in Birmingham Museum) having one front wheel for steering and two driving wheels behind, was intended for use on roads, not rails. In contrast to those two paragraphs, over five pages are devoted to the development by Edison and others of the incandescent light. But Faraday, who is not mentioned in the index, is only allowed one line, with the statement (on page 400) that he discovered the primary principles of the dynamo in 1831. This surely is a masterly understatement when it is realised that Faraday's discovery of electromagnetic induction (sixteen years before Edison was born) was the basis of nearly all the subsequent important developments in electrical engineering.

On pages 223 and 224 the author gives a table of many technical devices designed by Leonardo, but produces no evidence showing which were actually made or used ; in some cases similar devices were introduced independently by later inventors. The working of early textile machinery is admittedly difficult to describe but the explanations of Lee's stocking frame and Crompton's spinning mule are not clear. The woodcut of an early mandrel lathe, 1568, Fig. 134, was by Jost Amman, not Schopper (miscalled Schoffer on page 436). Fig. 129, showing a Newcomen engine of 1732 is copied from *The Steam Engine and its Inventors*, by R. L. Galloway, 1881, and it is a pity the author did not choose a contemporary and better illustration, e.g. Beighton's engraving of 1717 or Barney's of 1719. Fig. 130, purporting to show Watt's experimental condensing steam engine, is copied from *A History of the Steam Engine*, by R. H. Thurston, 1878. The author could easily have obtained a drawing or photograph of the actual engine (preserved in the Science Museum, London). It was not Wasbrough's patent of 1779, for a pawl and ratchet arrangement which proved useless, that was a serious obstacle to Watt, as stated on page 353, but Pickard's patent of 1780, which was assumed to cover the application to the steam engine of the crank and flywheel. Watt therefore devised his sun and planet gear and used it until Pickard's patent expired.

The pages dealing with steam turbines should have been amended. Fig. 157 is misleading ; as the author himself states " the schematic diagram, however, is not an adequate representation of the primary features of the Parsons turbine," we cannot see the point of reproducing it when better drawings are available. On page 396 it is stated that " The de Laval turbines were built for smaller units ranging from 5 h.p. up to several hundred horsepower. They revolved at very high speeds from 10,000 to 30,000 r.p.m. for the primary shaft." This implies that the larger turbines ran at the higher speeds, which is, of course, a reversal of the facts. Referring to Parsons turbines, the author writes : " The shaft speeds were lower, no more than 18,000 r.p.m. in the early days." He has missed the significant point that the d.c. generator as well as the turbine rotated at that extremely high speed, which contemporary engineers would not believe. Furthermore, electrical power was generated in a usable form without reduction gearing. Incidentally, modern de Laval turbines are multi-stage, not multiphase, as stated on page 396. The first marine turbine installation did not consist of three turbines yielding 2000 h.p., as quoted on page 397, but of one radial flow Parsons turbine driving a single shaft developing 960 h.p. at 2400 r.p.m., installed in the " Turbinia " (not " Turbina "), which was replaced later by three parallel-flow Parsons turbines. The turbine-driven " King Edward " was a Clyde river passenger steamer built in 1901 and was not designed for channel service in 1902. The author has probably confused it with " The Queen," constructed in 1903 for the Dover-Calais route. The statement that the destroyers " Viper " and " Cobra " were built between 1897 and 1902 is not sufficiently accurate, since it can be checked that both were commissioned and wrecked in 1901, tragedies which were not caused by the turbines.

Carl Benz built his first road vehicle driven by a light high-speed spirit motor in 1885, not 1878, as quoted on page 408. It had three wheels and was preceded in 1875 by the benzene driven vehicle, preserved in Vienna, of Siegfried Marcus. The statement on page 408 that " An important type of internal combustion engine was brought into practical use by Rudolf Diesel in 1895 " is incorrect. Herbert Akroyd Stuart (not Ackroyd-Stuart) began his experiments in 1886, obtained his two master patents in 1890 and by the end of the same year had twelve automatic ignition heavy oil engines running. Diesel obtained his first British patent in 1892, but his first satisfactory engine, built by M.A.N. in 1897, differed from his original proposals because his first experimental engine of 1893, designed to use coal dust as fuel, was a failure.

The gas turbine is surely one of the outstanding mechanical inventions during recent years in the production of power, but Professor Usher only devotes just over one page to the subject. He writes : " The rapidity of current developments and the secrecy shrouding some airplane jet engines would make any brief statement obsolete so quickly," and then adds : " No episode could demonstrate more explicitly the multiplicity of items of novelty embodied in achievements that we over-simplify because of the comprehensiveness of the ultimate synthesis." We suggest it would have been more helpful to students to recommend a selection of the numerous books, technical papers or articles published on gas turbines and jet engines since 1946. Part of his page is spent in rightly doubting a statement by Norman Davey in 1914 that " The theory of the gas turbine was as fully grasped by Barber at the end of the 18th century . . . as it is by the experts to-day." But was this statement worth repeating ? Barber's patent of 1791 has received considerable publicity in recent years, but we have seen no evidence that he made a gas turbine or that it would have delivered any appreciable power. This brief reference to gas turbines, possibly added without proper consideration, needs rewriting.

This volume contains too many names wrongly spelt ; for example, on page 122 *picotah* is the Indian name for the counterbalanced bailer (not *picotab*) ; on page 328 Thomas Earnshaw (not John) ; on page 338 Peter Morris or Moris, both names are used in contemporary accounts of London Bridge Waterworks (not Maurice) ; on pages 341 and 347 Morland (not Moreland) ; on pages 348 and 352 Beighton (not Breighton) and Chacewater (not Chasewater) ; on page 365 mandrel (not mondrel) ; on pages 371 and 436 Pirotechnia (not Piroteknika or Pirotechnica) ; on page 409 Holzwarth (not Holtzwarth) ; on page 427 Robison (not Robinson) ; on pages 427 and 429 Farey (not Farley) ; on page 446 Vitruvius (not Vitruius) ; on page 447 Kay (not Key).

It is unfortunate that this work, representing the collection of much interesting information over a long period, is of such variable quality. Before it was placed on the English market, parts should, in our opinion, have been rewritten with greater accuracy and conciseness. A typical example of the author's verbiage appears on page 32 : " We have lost all consciousness of the structure of the forest by concentration of attention on two or three kinds of trees." The equivalent English proverb contains seven words ! Readers unfamiliar with the theories held by the transcendentalists, the diffusionists and others, will not derive much help from the statement on page 46 that " This looking backward on the part of the historian is likely to lead to a spatialization of the time concept," but they may be relieved to learn on page 83 that " The completion of the analysis of the process of innovation will necessarily be the work of the psychologists." They will probably agree with the author that " We need only to know that the quality and importance of great achievements are due to the cumulative synthesis of a very large number of small achievements."

VDA-Handbuch "*Tatsachen und Zahlen aus der Kraftverkehrswirtschaft*, 1954/55." Nineteenth edition. Frankfurt a.M. 1955. Price 15 DM.—*Facts and Figures About the German Automobile Industry*, 1954/55, is a useful collection of data compiled by the Verband der Automobilindustrie, the German equivalent of the Society of Motor Manufacturers and Traders. It contains detailed production records of all German manufacturers making motor vehicles (including motor cycles and three-wheelers), trailers, and automobile accessories, and also data about imports, exports and new registrations. Of particular interest is the information about the German road system, which includes a survey of road accidents and a detailed analysis of their causes. An " International Part " deals with production, import and export figures of most automobile producing countries. This well-compiled book should be of considerable value to the economist, the statistician and everyone interested in the motor industry and in motorised traffic.

Mathematics for Engineers, Part I. By W. N. Rose, B.Sc. (Eng.). Ninth edition. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 21s.—This is one of the " Directly-Useful Technical Series," and aims to relate basic theory to practical application. Thus, in a chapter on the plotting of difficult curve equations there are t/ϕ diagrams for the Stirling, Joule and Ericsson engines. The present volume covers elementary and higher algebra, mensuration and graphs, and plane trigonometry.

Books Received

Power Plant Management. By R. H. Emerick. London : McGraw-Hill Publishing Co., Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 49s.

Statistical Year Book for 1953, Part II, Overseas Countries. London : British Iron and Steel Federation, Steel House, Tothill Street, Westminster, S.W.1. Price 15s.

Statistical Year Book for 1954, United Kingdom Statistics. London : British Iron and Steel Federation, Steel House, Tothill Street, Westminster, S.W.1. Price 7s. 6d.

Combustion Researches and Reviews, 1955. Papers presented at the 6th and 7th AGARD Combustion Panel Meetings. London : Butterworths Scientific Publications, 88, Kingsway, W.C.2. Price 35s.

S.B.A.C. Flying Display and Exhibition

No. I

THE sixteenth Flying Display and Exhibition organised by the Society of British Aircraft Constructors, at Farnborough Aerodrome, Hampshire, commenced on September 5th and is open to the public on September 9th, 10th and 11th. Many of the newer aircraft were, of course, security restricted, and only superficial descriptions can be given. Some of the demonstrations are described below.

An early highlight of the flying display was the first public hearing of a by-pass engine when an Avro "Ashton" with a Rolls-Royce "Conway" installed in a pod beneath the fuselage was demonstrated; when seen in the park the air intake was protected by a hinged grid. The aircraft climbed steadily and steeply away from the field, the "Conway" smoking lightly at the beginning and end of the climb. It is interesting to recall that the Rolls-Royce-engined "Tudor VIII," a civil version of the "Ashton," was the only jet airliner in existence when it appeared at this exhibition in 1948.

At the same time two Napier turbines were flown, the "Double Mamba" in a Fairey "Gannet" trainer, and the "Eland" in an Airspeed "Ambassador."

A noteworthy item in the lighter aircraft that followed was the take-off of the Scottish Aviation "Prestwick Pioneer," which in a wind of about 15 m.p.h. became airborne in no more than its own length.

The English Electric "Canberra" with Bristol "Olympus" engines appeared with its new record altitude of 65,876ft painted on the fuselage below the previous record, held since May, 1953.

The helicopter contribution in the flying programme was active and varied. The Bristol "173," a model of which we illustrated in our issue of September 18, 1953, on page 375, flew past first fast, then slowly in a marked nose-up attitude, and finally backwards. The new Fairey "Ultra-Light" helicopter is intended to provide air reconnaissance facilities for Army tactical purposes, and it can be carried complete upon a 3-ton truck. For ground handling the aircraft can be carried by bars fitted to the undercarriage tubes. The rotor is driven by jets at the blade tips, supplied with compressed air by a Blackburn-Turbomeco "Palouste"; this method of rotor drive does not produce torque reaction and consequently no auxiliary rotor is needed. The tail has a small rudder located below the boom, and not behind as in Fig. 4; the square boom is jointed immediately above the turbine with four bolts, and it would appear to be possible either to remove it completely or hinge it upwards. The model flown was a single-seater with a large instrument board and ballast on the front of the skids, but a dual control two-seater stood in the static exhibition. In flight the little rotorcraft was quite fast, although noisy.

Another Fairey helicopter, the "Jet Gyrodyne," demonstrated the conversion from powered lift to pure aerodynamic lift. This aircraft is an experimental model to give data for the "Rotodyne," which will fly with 50 per cent of its lift provided by an auto-rotating rotor; the virtue of this system is that, in the event of engine failure, there is no delay in attaining auto-rotation. Landing in autogyro flight, the aircraft approached slowly and rolled a short distance before taxi-ing away.

The Short "Seamew" demonstrated powered wing folding as four aircraft taxied on to the runway. As so often on carrier-borne aircraft, the aerofoils are far from straightforward. The slotted flaps extend from fuselage to aileron, having to be divided where the wing folds, and at the outer end letterbox slots produce the effect of a Venetian blind flap; a short length of fixed slat is carried near midspan, opposite the junction of flap and aileron. The rudder is hinged well back from the leading edge and has a horn balance, while the vented fillet of the tailplane, visible in Fig. 2, discharges along the top of its lower portion. The compactness of the "Mamba" engine allows the crew to sit right in the nose of the machine with an excellent downward view. Provision is made for alternative wheel sizes to suit the aircraft for operation either from steel decks or sandy beaches. The wing folds about two pivots, at roughly 45 deg. in ahead view, and raked in side view to raise the wing tip.

Fig. 2—A Short "Seamew" lands on H.M.S. "Bulwark." The large flaps, the short fixed slats and the vented fillet in the tailplane can be seen

Fig. 1—The Fairey "Delta 2." The thinness of the wing section is advertised by the fairings necessary over the power controls of the ailerons

The group of commercial aircraft was led by the Scottish Aviation "Twin Pioneer" and the Handley Page "Herald," described more fully below, and then the muted turboprop "Britannia" gave place to a succession of jet aircraft. Many of these were familiar—the "Victor," "Valiant," and "Vulcan" were illustrated in these columns on September 11, 1953, but a few points of interest are recorded. The Handley Page "Victor," both at take-off and landing, had sections of its leading edge dropped, the inner slightly further, but was not seen to use the dive brakes on the sides of the after-body. The Vickers-Armstrong "Valiant," on which the front part of the tailplane is fixed, had small vortex generators on each face of the fin and tailplane near their junction. The delta Avro "Vulcan" appears to guard against power control failures by having each of its eight control surfaces independently operated; on each wing the inner pair

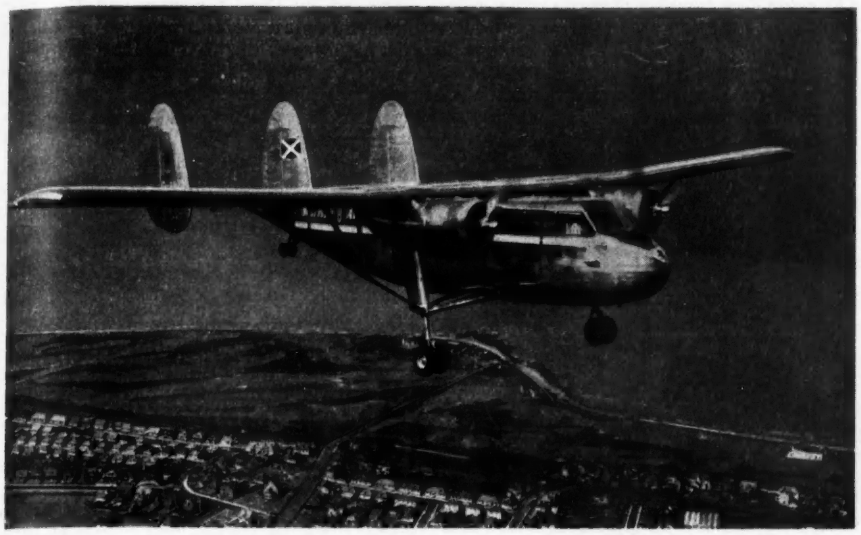


Fig. 3—The Scottish Aviation "Twin Pioneer" in flight. It has a maximum cruising speed of 174 m.p.h.

responds to pitch demands and the outer to roll. The effectiveness of the controls and the strength of the structure were convincingly demonstrated by a slow roll. At landing, the four big dive brakes were extended throughout, the combination of sweepback and full up elevator resulting in an immense ground angle at touchdown.

The Folland "Gnat" was described in our account of the 1954 exhibition, where its forerunner, the "Midge," performed. An unusual feature of the aircraft is the interconnection of undercarriage and ailerons (see Fig. 7), and it was seen when the "Gnat" took off that the wheels were left down until the turn away from the runway had commenced. The "Gnat" was able to make a circuit within sight of the aircraft, and on landing released a brake parachute and towed it off the runway. The undercarriage has levered suspension, and the linkage seen in our illustration is merely an anchorage for the retracting jack. It was announced last week that the compactness of the aircraft—span 22ft 2in, length 28ft 9in—is to be capitalised in a "Sea Gnat," which, without wing folding, will take up one-half, or less, the space needed by current fighter in an aircraft carrier's hangar.

The Avro-Canada "C.F. 100" was the first combination of Dominion-built airframe and engines ever to fly at this show; it shows marked resemblances to the Gloster twin-jet fighters. Conspicuous immediately within each air intake is a two-bladed windmill spreading alcohol for de-icing purposes over the air intake grille. Behind the pack of eight 0·5in guns a "frill" of sheet metal fingers deflects spent cartridge cases.

The Supermarine "Swift" appeared as the "F.R.5" fighter reconnaissance version. The forward set tail surfaces give an impression of a flying engine nacelle, and the demonstration take-off with reheat power showed that great thrust was available. In front of the aileron the leading edge is extended forward, giving a notched appearance in the plan view. Earlier "Swifts" have had a boundary layer fence inboard of the aileron, and this no longer appears. A second Hawker-Siddeley twin-engined fighter, the Gloster "Javelin," emulated the "C.F.100" with an upward roll into an outside loop.

The Fairey "Delta 2" (Fig. 1), a research aircraft powered by a reheat Avon, has its nose hinged immediately aft of the cockpit to drop and allow increased downward visibility for the pilot at landing. The delta flew only at low speeds, but showed a vigorous rate of roll. Dive brakes are fitted on each side of the fuselage, but there are no flaps and the ground angle is again large. A cluster of three parachutes restricts the landing run. Even with powered flying controls the moving nose would appear to be a heavy and expensive provision, and suggests that future aircraft of this configuration would be much larger.

The English Electric "P.1" gave a restrained display including a convincing slow fly-past. Some impression of the design of this supersonic fighter can be gained from Fig. 6, in conjunction with the ground view printed on September 10, 1954. The swept tailplane moves in one piece, and the ailerons run straight across the wing tips: long flaps parallel with the trailing edge allow a normal approach and landing.

Fig. 5—Hawker Hunter "F.1s" of No. 54 Squadron, Royal Air Force, performed at Farnborough.

Fig. 4—In the Fairey ultra-light helicopter an observer can sit on the port side facing either forward or aft

Civil Aircraft

The Handley Page "Herald" airliner and freighter (Fig. 9) is intended for the widest use in medium-range commercial flying. Its maximum take-off weight of 34,000 lb allows a payload of 10,705 lb, equivalent to thirty-six passengers and 26 cwt of freight for 280 miles, or twenty-one passengers for 1650 miles; forty-four tourist passengers or freight alone could be carried, seats and partitions being removable. Because flight altitudes may be forced up by mountains or bad weather to over 15,000ft, the "Herald" is pressurised to a cabin altitude of 6500ft at this height. The fuselage is not completely circular in cross-section, the radius of curvature being much greater for the part below floor level; it is a semi-monocoque with the stressed skin stiffened by stringers welded on. A two-part door over 5ft. square is about 4ft from the ground at the rear of the

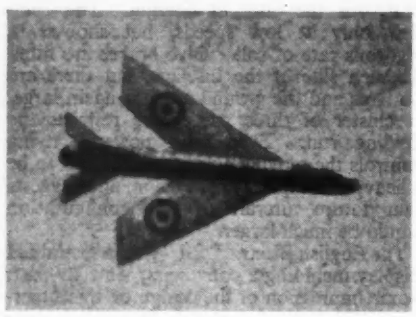


Fig. 6—The English Electric "P.1" in flight. The horizontal tail surfaces are all-moving

cabin. A single tail unit with fluted skinning has control surfaces balanced both by tabs and horns. The wing is straight and tapered, the centre section carrying the four engines, and the extending auxiliary aerofoil flaps overlap the outer sections. Slats are not incorporated. The twin-wheel main undercarriage legs retract forward into the long untapered nacelles behind the inner engines, the steerable nose wheels stowing in front of the pressure hull. De-icing is provided for the windscreen and all aerofoils; 3000 lb per square inch hydraulics operate the major services, and the electric system is 24V. The Alvis "Leonides Major" engines, described in these columns, September 18, 1953, are installed in tulip-petal cowlings and give cruising speeds as high as 230 m.p.h.

The Scottish Aviation "Twin Pioneer" sets out to operate where other aircraft cannot; even on a grass runway at 100 deg. Fah. it reaches 50ft in less than two furlongs at sea level with 22 cwt payload and fuel for a 500-mile stage. The speed range is almost 4 : 1, from 48 m.p.h. to 180 m.p.h. Designing for such difficult conditions naturally incurs penalties, and the empty weight of a sixteen-passenger version is 9075 lb. The aircraft has a braced high wing, the untapered outer sections carrying full-length slats and slotted ailerons, while Fowler flaps of 30 per cent chord occupy the remainder of the trailing edge. The centre section incorporates fixed slots. There are three fins and rudders; a tail-wheel undercarriage is adopted with a view to operation on rough surfaces. Each unit has two wheels, and the main legs have hydraulic disc brakes. Flaps, slats, windscreen wipers are also hydraulic. The fuselage has baggage compartments below the control cabin and behind a main cabin of 530 cubic feet capacity; part of the main door forms a gangway, and an adjacent door gives a 4ft wide entrance. Instruments include a Sperry A.L.I. auto-pilot; V.H.F. and beam approach radio is installed under the hinged nose panel. Liquid de-icing is provided for all aerofoils, windscreens and carburetters; the engines are Alvis "Leonides" 503/8 of 540 h.p.

Static Display

The National Gas Turbine Establishment is demonstrating in a wind tunnel the jet flap. This is the name given to a system in which the propulsive jet is blown in a thin sheet from a slot along the trailing edge of an aerofoil, and it offers a means of controlling lift independently of incidence. This is, of course, a valuable feature of such a device, as it is noticeable that incidence range extending systems are not at present welcome; even the Handley Page "Herald" has no slots. It is already established* that such a jet, emitted from the trailing edge tangential to the camber line, increases the lift force by as much as five times the downward component of the jet reaction. The "flap" as shown in Fig. 8 acts at an angle to the chord line, and its function is most conveniently expressed by considering flow in an inviscid fluid with a superimposed circulation. On a conventional aerofoil a circulation is postulated such that the stagnation streamline prolongs the camber line at the trailing edge (Joukowski hypothesis), but with the jet flap the stagnation streamline must be embraced by the jet stream and thus the circulation must increase with "flap" angle. The influence of the jet upon the streamlines depends upon its momentum; the path of the wake will be governed by an equation of the form $\partial p/\partial r = mv^2/r$, where r is the radius of curvature and mv the mass flow for unit span: the pressure distribution will clearly be modified if the jet velocity differs from the local stream velocity. Since, at a point far downstream, the jet sheet will be turned into the stream direction, we deduce that there will be a thrust upon the wing equal in magnitude to the reaction of the jet. The idealised theory has marked limitations and, in fact, mixing of the jet and the main flow modifies conditions in several ways. Entrainment of air above the wing may delay or even suppress the stall, and even more entrainment occurs from the air below the wing; change of mass flow in a region of varying pressure may result in the thrust being either less or greater than the jet reaction. The difference between the thrust and the thrust component of the jet reaction appears as a form, or pressure, thrust. The experimental results are expressed by the use of a coefficient $C_J = \dfrac{\text{Jet Thrust}}{\frac{1}{2}\rho V^2 \times \text{Wing Area}}$.

A graph displayed on the stand shows that, for the 58 deg. flap illustrated, at $C_J = 4$ lift coefficient reached a sharply defined maximum of 11 at an incidence of about $-\frac{1}{2}$ deg.: values of C_L up to 12·5 have been obtained in wind tunnel work.

(To be continued)

Fig. 9—The Handley Page "Herald" landing after its maiden flight

* Helmbold, "Lift of a Blowing Wing," *Journal of the Aeronautical Sciences*, Vol. 22, No. 5, May, 1955.

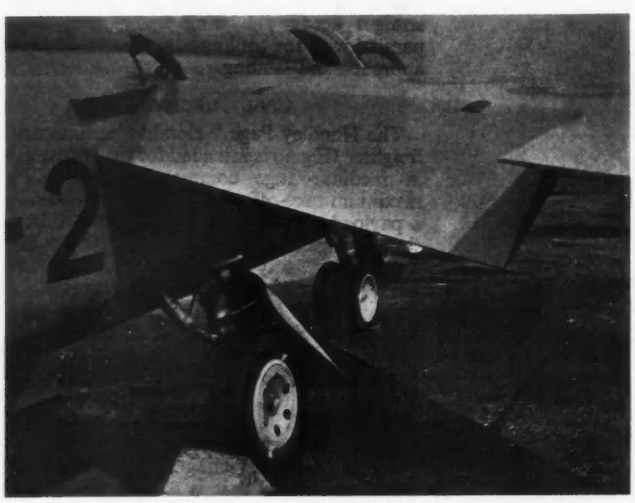


Fig. 7—The ailerons of the "Gnat" droop when the undercarriage is fully extended: here the droop is accentuated by control movement

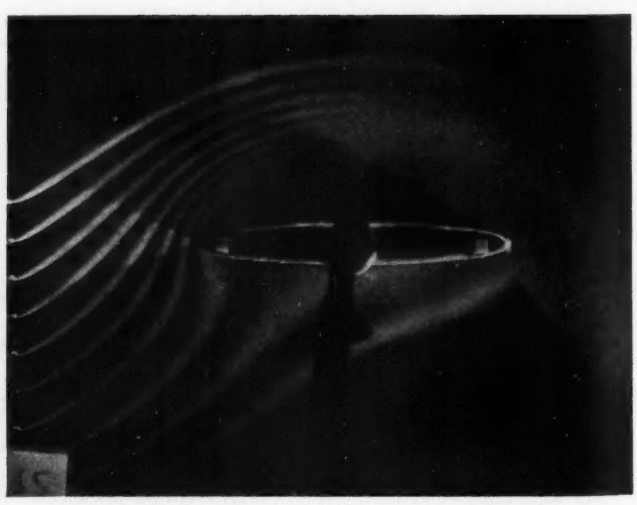


Fig. 8—In a wind tunnel it is seen that a jet flap at 58 deg. can induce marked circulation about an aerofoil at 0 deg. incidence

North of Scotland Hydro-Electric Schemes

No. VI—THE TUMMEL-GARRY SCHEME,* PART II

(*Continued from page 339, September 2nd*)

Last week we described the Tummel–Garry scheme generally, and the earlier hydro-electric works nearby. We continue with a more detailed account of the Errochty section of the scheme, which is now approaching completion. Errochty dam is described in this part of our article, which also includes a résumé of contemporary ideas on buttress dam design as they are expressed by recent work in Scotland.

THE second stage of the Tummel-Garry scheme is simple in its layout. It comprises a reservoir on the upper reaches of Errochty water, formed by a diamond-headed buttress dam, then a tunnel, 28,500ft in length, leading to a surge chamber with vertical shaft below it, from which 1650ft of pressure tunnel, followed by a trifurcation into three buried steel pipelines, continues to the power station beside Loch Tummel. There are also aqueducts bringing additional water into the reservoir, as shown in Fig. 1 in last week's issue ; the leading data of the reservoir and power stations were also given last week in Tables I and II.

From the civil engineering standpoint the most interesting part of the scheme is the dam. This structure consists of a number of buttresses each statically independent of its neighbours ; a typical buttress is shown in Fig. 9, which shows the proportions of the dam generally, and Fig. 10 shows constructional work in progress at the site. This form of dam is one of the various solutions which have been put forward to the problem of replacing the conventional gravity dam by a more efficient and economical structure. The diamond shape of the upstream face of the buttress is intended to concentrate the hydrostatic thrust acting on it into the comparatively small thickness of the web of the buttress, and at the same time avoid tensile forces in the head. The sloping upstream face is advantageous in keeping the line of resultant thrust within the permissible limits of the base of the buttress, with the maximum economy of material. In this particular design, with a maximum height of 130ft and a length of 1120ft (for the buttress part only—there are solid gravity sections at each end adding a further 180ft to the total length of the dam) the volume of concrete is about 175,000 cubic yards, which it is estimated gives a theoretical saving of 35,000 cubic yards over a straightforward gravity dam. This saving has to be offset, to some extent, by more complicated shuttering ; the actual increase in shuttering is difficult to estimate, for there are less " stop-end " shutters needed than with a gravity dam, and some authorities maintain that the total area to be shuttered is about the same in both cases, although a lower standard can be accepted in the " stop-ends " of the gravity dam.

One of the problems in the design of such a dam is that of fixing the width of a buttress. If it is too wide it may have to be thickened excessively to avoid tensile stresses ; if it is too narrow, the full advantage of the design may be lost by additional shuttering complications. The most economic width, for a given height, depends on ruling circumstances, such as relative costs of concrete and shuttering. The width of the buttresses at Errochty is 40ft, in every case, and there are twenty-eight buttresses altogether. This width was chosen as the optimum for the various heights of buttress which had to be built, taking into account also the special shape of the buttresses of the spillway section of the dam, where they are widened to give a continuous downstream face.

The dam foundation consists of mica schist rock, which, it was anticipated, might be of rather poor quality. This fact influenced the design of the dam in favour of the solid-headed buttress configuration, for each buttress could be made statically independent, and any settlement which might occur could be accommodated with greater safety by the individual buttresses than by a continuous structure. A typical joint detail between contiguous buttresses is shown in Fig. 9. It may be observed that the buttresses are not keyed into each other, but are structurally completely independent, and their abutting surfaces are coated with bitumen. The watertight seals consist of a central 6in diameter core of bitumen, with a steam pipe down the centre of it, so that the bitumen may be heated and reconsolidated, if required. Upstream of the core there is a U-shaped flexible copper strip waterstop, and downstream a Z-shaped copper seal ; these strips are flexible enough to allow relative movement of adjacent buttresses, but at the same time prevent water from entering or bitumen from extruding from the central core. When construction was started it was found that the foundation conditions were less satisfactory than had been anticipated, and the footings of the dam were widened and deepened so as to limit the stresses at formation level. A loading test was carried out to confirm the suitability of the reduced stresses adopted for the foundations from the modified design.

Some Contemporary Dam Designs

The variety in the design of some of the recent Scottish dams is worth comment, and so we have digressed here from our description of Errochty dam and grouped together in Fig. 8 details of the Sloy, Giorra, Shira and Errochty dams, and also of Haweswater dam, all of which represent attempts to obtain a more rational and economical structure than the conventional gravity dam. The design problem common to such attempts has, of course, been studied for many years, and on many sites where an arch dam was not a feasible alternative to a gravity dam. A dam consisting of an inclined slab of reinforced concrete, carried at intervals on buttresses (the Ambursen dam) was one solution. Alternatively, the multiple arch dam was proposed in which inclined arches span between the buttresses, thus eliminating the tensile forces of the reinforced concrete slabs. A recent example of an elaboration of the multiple arch principle is the French dam of La Girotte (The Engineer, December 14, 1951). A different method of concentrating the water load into relatively thin buttresses was proposed by Noetzli ; he suggested the roundhead buttress design, in which each buttress, which is statically independent, consists of a thickened upstream head, which is rounded to direct the water load into the webs of the buttress with purely compressive forces. The diamond-headed buttress dam is a variant of this idea, the straight upstream faces of the buttress being intended as a constructional simplification over the curved surface. An analysis of the forces in a buttress was given by the American engineer Schorer in 1930.†

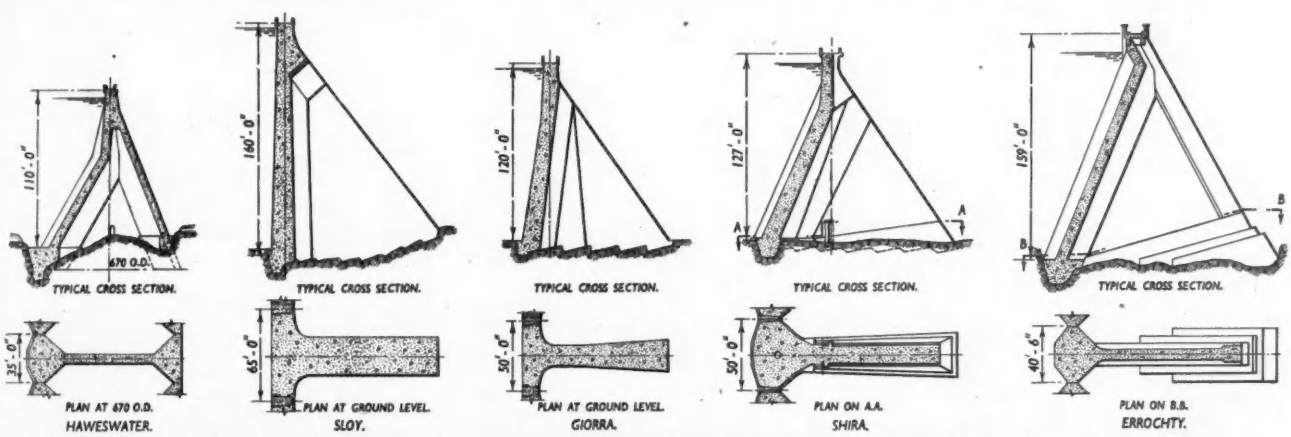


Fig. 8—This comparative illustration shows, to the same scale, the Haweswater dam and various buttress dam designs used for the North of Scotland Hydro-Electric Board's schemes

* No. I : " An Introductory Survey," appeared July 14, 1950 ; No. II : " The Loch Sloy Project," July 21-August 4, 1950 ; No. III : " The Fannich Project," June 8-15, 1951 ; No. IV : " The Mullardoch-Fasnakyle-Affric Project," April 11-25, 1952 ; No. V : " Some Schemes for Local Supply," October 16-23, 1953.

† " The Buttressed Dam of Uniform Strength," by H. Schorer. *Proc. A.S.C.E.*, Vol. 56, November, 1930, page 1947.

At about the same time the advantages of a buttress dam with a thickened upstream head were being investigated in this country, and the Haweswater dam, which was the first British example of a "lightened" gravity structure, was built and completed in the 'thirties. In this dam the diamond-headed configuration was adopted and the downstream faces of the buttresses were also thickened to give a continuous downstream face. The designers considered that the splayed "tails" gave greater lateral stability and resistance against buckling under load than the normal rectangular buttress. Many variations are possible in the way in which the basic idea is carried out in practice; a comparison with the hollow dams built in Italy (see THE ENGINEER, March 6, 1953) is of interest.

The Loch Sloy dam was designed from a rather different standpoint (Sloy dam was completed in 1951, but similar designs are at present being built for the Lawers and Breadalbane schemes). The first advantage aimed at in the underlying design conception was the elimination of uplift pressure over a large area, which could be achieved by leaving open joints in a solid gravity dam. The dam was then further lightened by opening out the joints, thus reducing it to a series of buttresses in plan, leaving the upstream face thick enough to avoid tensile forces. Dams of similar form have been built in Italy at Scais and S. Giacomo (THE ENGINEER, March 13 and 20, 1953). The latter is a far larger structure than the Sloy dam, but the Sloy dam is a bolder design in that the arcading of the buttresses gives it a more graceful appearance than its Italian counterpart.

Since the completion of Sloy dam, the massive buttress design has been modified and improved; a detailed account of its advantages and evolution was given at the Fifth Congress on Large Dams held in Paris last June,‡ when the relative merits of different dam designs was one of the subjects discussed. Briefly, the aim has been to simplify the design as much as possible and to improve the speed of construction. The Giorra dam of the Breadalbane scheme exemplifies these modifications. The dimensions of the buttresses have been altered, but maintained of convenient size for mass concreting methods of construction. Minor details are precast, but the precast arches carrying the roadway in the Sloy design have been eliminated, and the dam can now be built to its full height with the standard climbing shutters. The cost of this dam is claimed to be 70 per cent of the cost of the comparable solid gravity dam.

In a general discussion of this kind, it should also be mentioned that attempts to improve on the normal gravity dam along rather different lines from those just described are also being made in contemporary Scottish hydro-electric work. The Loyne and Cluanie dams of the Moriston scheme, whilst retaining the normal solid gravity characteristics will be made more economical structures by the incorporation of blast-furnace slag in place of part of the normal content of Portland cement. The slag is ground at the site, by the Trief process, and it is estimated that 20,000 tons of cement will be saved by its use. The Loyne dam will be

‡ Paper R.61. "The Design and Economics of Massive Buttress Dams," by E. J. K. Chapman and D. F. Campbell.

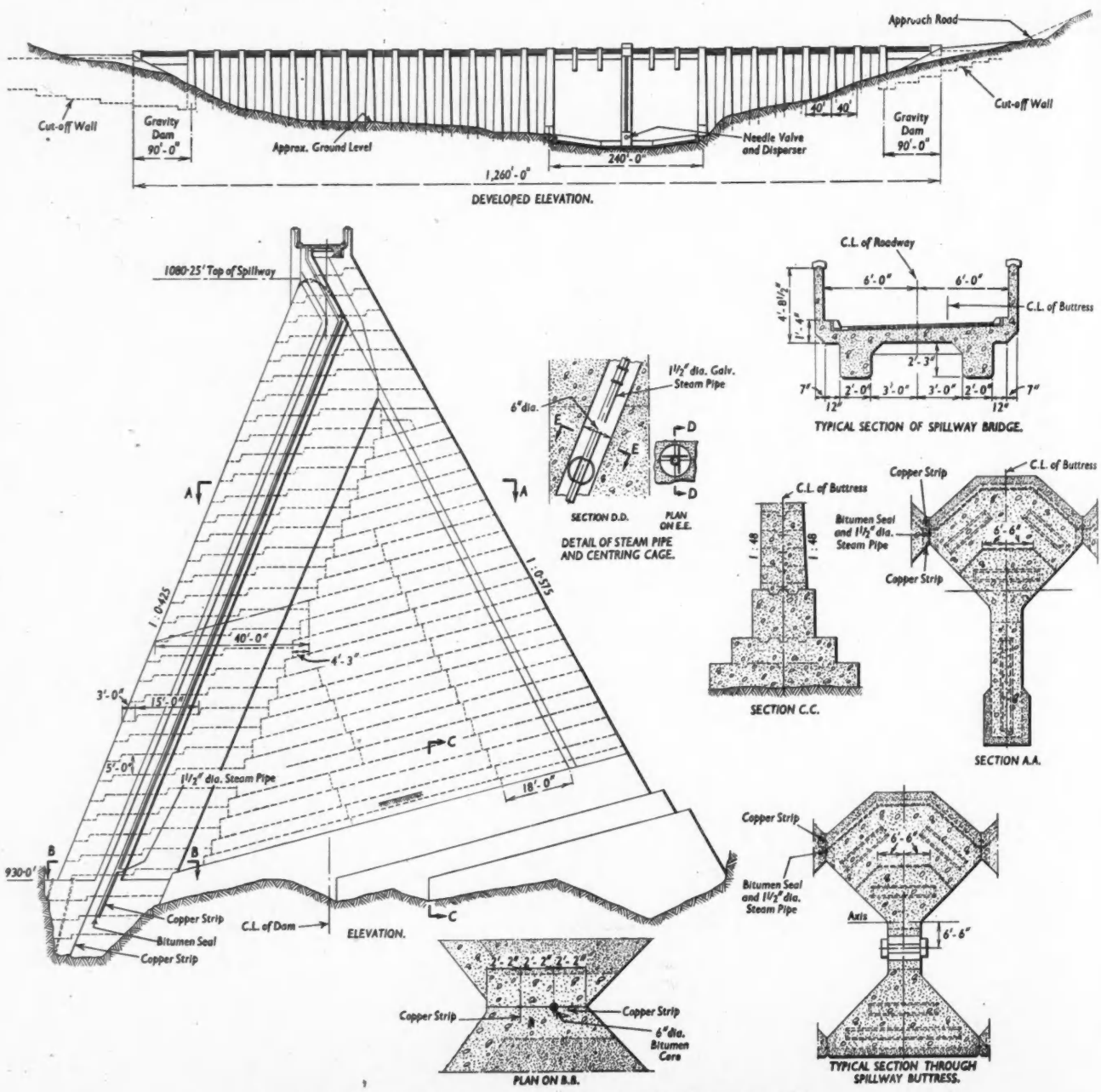


Fig. 9—Details of Errochty dam. The dam is a diamond-headed buttress structure

Fig. 10—Construction of Errochty dam in progress. The gap in the centre is where one buttress was left low enough for the river water to flow over it during construction. On completion of the scour culvert, the stream was diverted through the channel in the foreground, to the culvert, thus allowing the last buttress to be built up

58ft high and 1745ft in length, and the Cluanie dam 112ft high and 2165ft in length. Yet another approach involves prestressing the dam, with vertical prestressing tendons anchored in the rock below the upstream face, and extending to the top of the dam, to give an additional downward force which, in effect, replaces the gravitational force exerted by part of the bulk of the dam. A prestressed concrete dam is under construction at Allt-na-Lairige with a height of 83ft. It was briefly described in THE ENGINEER of June 17th last, page 851.

Returning, however, to the various "lightened" gravity dams, the basic advantage claimed is, of course, a saving in concrete due to a more rational structural form. But other advantages are generally apparent with these designs. Uplift pressure on the dam is substantially reduced, the base can be made wider for a given height, thus giving greater stability, and the cooling of the newly placed concrete is much easier than with the large masses of the gravity dam. Furthermore, the shrinkage of the "green" concrete can be more readily accommodated and maintenance of the completed structure is claimed to be more simple. It has also been pointed out that shuttering costs are only a small proportion of the concrete costs, and it is doubtful whether the total shuttering cost is significantly altered by the adoption of such designs. Against these advantages, it has been pointed out that the cut-off under the upstream face of the dam is more critical with the buttress designs, and the increased complexity of the shuttering may result in slower construction. Also, some of the concrete must be richer in cement than with a gravity dam, and foundation costs may be higher. Apart from the potential weakness at the cut-off, great care must also be taken with the roundhead and diamond-headed buttress dams to avoid cracks on the upstream face; thus it has been said that such designs are vulnerable to frost damage in cold climates.

In commenting on these various designs, our intention has been simply to show some of the differing schools of thoughts behind the constructional work going on to-day, and how different technical ideas are interpreted in practice. The construction of a dam is very much an individual problem; differing site conditions, both physical and economic, and other practical factors have doubtless had their influence in producing the various shapes we have described. The exact shape chosen must be found empirically, and provided that the theoretical requirements of the structure are complied with, the final details will be governed by economic considerations. Here the problem for the designers of the Scottish dams has been very difficult—for conditions such as rates of labour and prices of materials have been changing throughout the period of design and construction. But it is certainly an encouraging circumstance for the civil engineer to find these diverse examples under construction in Scotland at the same time, particularly since the principles embodied in Haweswater dam seem to have been neglected in the intervening years. Table III lists the maximum principal stresses in the three Scottish buttress designs, and some dimensions and volumes are given in Table IV.

DESIGN OF ERROCHTY DAM

We noted earlier that the foundation conditions at the Errochty site were favourable to the buttress design. But it was considered that, under the conditions prevailing at the time the dam was designed, a considerable saving in concrete would be needed to justify such a dam, for the cost of skilled labour for shuttering was high, and such labour was scarce. Nevertheless, a comparison indicated that the relative cost of buttress, solid gravity and rock fill dams would have been roughly about 1, 1·2, 1·4 respectively, and as there were various technical reasons in its favour, the buttress design was adopted. Needless to say, the cost ratios just mentioned would probably not be applicable now owing to the way economic conditions have changed during the past few years.

The basic design of the dam, as with other kinds of buttress dam, follows along the same lines as the design of a normal solid gravity dam. The "middle third rule" does not apply, but the resultant force must be made to fall within the permissible zone of the base to avoid tension, and the dam must be analysed for stability against sliding and overturning. But there are additional complications in analysing stresses in such a complex structure, the buttress heads presenting a particularly intractable design problem; so in the case of Errochty dam model experiments were carried out to check the analytical work. The main aim of the model experiments was to verify whether any serious tensile stresses would be developed in the head of the buttress. The following paragraphs are reproduced from a paper published by the Institution of Civil Engineers§ to illustrate this aspect of the design.

"The calculation of the stresses in a structure of this type is rather difficult and it does not readily lend itself to analysis by Airy stress functions or even by relaxation. In addition, there are many factors difficult to assess, but which may have considerable effect on the stress distribution in the dam. Examples are: non-homogeneity of concrete and its non-linear stress-strain character-

TABLE III—*Maximum Theoretical Stresses in Certain Scottish Dams*

Dam	Errochty dam		Shira dam		Giorra dam	
	Reservoir full	Reservoir empty	Reservoir full	Reservoir empty	Reservoir full	Reservoir empty
Distance below top water level, feet	150		135		120	
Maximum principal stress in buttress head, pounds per square inch	73	119	60	110	52 (At upstream face)	108
Maximum principal stress in buttress web, pounds per square inch	262	110	225	75	225 (At downstream face)	43
Maximum principal stress at formation level, pounds per square inch	96	112	135	105	186	86

TABLE IV—*Dimensions of Various Buttress Dams*

Dam	Haweswater	Sloy	Giorra	Shira	Errochty
Maximum height of dam (from ground or stream bed level to T.W.L.), feet	100	160	120	135	130
Length of buttress section, feet	1,540	1,160	815	1,800	1,120
Concrete volume of buttress section, cubic yards	140,000	200,000	45,500	240,000	175,000
Estimated saving over comparable gravity dam, cubic yards	52,000	50,000	26,000	50,000	35,000
"Pitch" of one buttress, feet	35	65	50	50	40

§ "Photoelastic Experiments on the Stress Distribution in a Diamond Head Buttress Dam," by Professor A. W. Hendry. *Journal I.C.E.*, Part I, Vol. 3, No. 3, May, 1954.

istics, shrinkage and thermal stresses, and uncertain conditions at the foundations. Thus, great accuracy in the stress calculations is not to be expected and the design method of analysis is based on elementary statical principles. It was the object of this model investigation to obtain a check on the validity of these calculations in the buttress web and to secure information concerning the stress distribution in the diamond head. To achieve the first, an analysis of the model under the loading applied to it was carried out, using the same method as adopted in the design of the full-sized structure. The results of this analysis were compared with the experimental results ; no attempt was made to 'scale up' the model stresses for comparison with the design stresses for the prototype, on the argument that if the method of calculation gave the stresses in a small structure it would do so in a large structure of the same shape. Agreement would indicate that the method of calculation provided a reliable estimate of the primary stresses in an idealised structure ; allowance for the complicating factors mentioned above would have to be made separately or covered by the factor of safety.

"The stresses within the diamond head are not readily calculable by simple means and the experimental results were required to give a quantitative indication of the stress conditions which might be expected in the full-size structure. The only feasible experimental method of obtaining these results was by the 'frozen stress' method of photo-elasticity. In the present tests most of the stress systems examined were such that they could be regarded as approximating to two-dimensional systems. The freezing and slicing technique was, however, essential for studying the stress distribution in the buttress head and, in addition, the use of the freezing methods made it possible to obtain measurable optical effects from the application of comparatively small loads.

"Agreement between calculated and experimental results was reasonable, and it was concluded that the method of calculation gave a reliable estimate of the primary stresses in the buttress web of an actual dam of the shape investigated. It was obvious, however, that the ideal conditions assumed in the calculations are difficult to obtain in practice, even in a laboratory experiment ; thus due allowance would have to be made in design for such contingencies as shrinkage, unknown base conditions, and the like.

"The maximum stresses in the head of the dam are those arising from hydrostatic pressure ; those resulting from gravity are comparatively small. The head is not so highly stressed as the buttress web and no dangerous stresses were observed. The experiments confirmed that a circular hole could safely be made through the head and that a comparatively large gate shaft could be formed in it without substantially increasing the stresses. In both cases, however, the need was evident for careful detailing and reinforcement to deal with local stress concentrations around these holes."

Constructional Works at Errochty Dam Site

Concrete is being placed in the Errochty dam at a rate of up to 3500 cubic yards per week. This maximum rate has been reached during the summer months, with day and night shifts at work. Aggregates are obtained from a crushing plant situated upstream of the dam alongside the future reservoir, where spoil from the Garry-Errochty tunnel is available. The rock used is schist. Cement comes by road, and sand from a pit at Newtonmore, which the contractor opened so as to have a source of his own for the work at Errochty dam.

The graded aggregates are brought to the dam site by dumper and stored in silos each of 900–1000 tons capacity, holding, respectively, the 3in-1½in, 1½in-¾in, ¾in-⅜in, ⅜in-$\frac{3}{16}$in sieve separations and sand. A rather unusual layout has been adopted here, as the weighing plant is situated beneath each storage hopper, and the weighed aggregates are then taken by belt conveyor to a "dry" hopper above the concrete mixer. There are two 2 cubic yard concrete mixers and the plant has been laid out in two identical sets, each supplying one of the mixers. Thus, there are two sets of five silos with weighing gear beneath each silo, and two sets of belt conveyors, one for each mixer. The control of all the weighing is, however, effected on central panels (one for each mixer) and embodies the various automatic safeguards which are now generally employed on this class of work. Cement is added at the "dry" hopper above each mixer, and then the dry constituents and the water are discharged into the mixer. There is a "wet" hopper of 6 cubic yards capacity under each of the two mixers, from which the concrete is discharged to 3 cubic yard skips. There are two 7½-ton cableways spanning the site which place most of the concrete, but for the work on the left bank side, near the concrete plant, skips may be taken by lorry for emplacement by the derricks which have been provided along this part of the dam. The cableways do not have tail carriages moving on rails, such as are often provided, but sufficient coverage is obtained by having luffing head mast structures at each end, which can be "luffed", about 25ft to either side and so vary the path of the cableway.

Concrete in the webs of the buttresses is placed about two lifts in advance of concrete in the buttress heads, as this sequence gives more convenience in manipulating the shuttering. Emplacement of the concrete in the narrow width of the buttress web has been found to be a tricky task. The web construction joints are formed at an inclination of 1 in 4, upwards towards the downstream face, but the lifts in the heads have horizontal stepped joint surfaces as indicated in Fig. 8. Generally the lifts are 5ft in depth. The concrete mix for the upstream face is 1 : 5 by weight, and about 1 : 6·25 for the remainder with water/cement ratios varying from 0·47 to 0·55. A close control over the concrete quality is achieved, there being a small laboratory on the site to control this aspect of the work. The average strength achieved with seven-day cube tests has been about 4000 lb per square inch with a standard deviation of about ±500 lb per square inch. The close grading of the aggregates, with four sizes of coarse aggregate, was justified on investigation, for it was found that segregation tended to take place in the storage bins. The quality control of the concrete at this site was discussed in a recent paper.‖

The basic shuttering unit is a steel panel with soldiers and bolts to give the usual "climbing" shutter associated with the construction of dams. As the cableways are generally fully occupied in placing concrete, the transfer of shuttering from one buttress to another is avoided as far as possible. Shearlegs, made of light alloy for easy handling, are provided on each buttress for raising the shuttering. Setting the shuttering to its correct line is one of the more tedious tasks on a structure of such shape (it is curved in plan), as almost all the shuttering planes are inclined. Up to about ten engineers, drawn from both the consultants' and the contractors' staffs, are engaged on this work, more or less full-time, when the concreting is going at full speed.

The dam has the usual cut-off trench close to its upstream face, where grouting is being carried out up to pressures of 190 lb per square inch and with holes drilled to depths up to 120ft. One unusual difficulty encountered during the excavation for the dam was caused by the presence in the left bank of thin seams of silt in the schists on which the dam is founded. These schists are very hard, but are much cracked and fissured. Geologically the presence of the silt seams is probably due to alternate freezing and thawing, which first opened fissures and then allowed water to percolate, bringing silt with it, which after many repetitions eventually built up into seams as thick as 6in. A number of these seams of silt were encountered. The silt was jetted out, where present in critical places, and the seam was refilled with cement grout. Small test pits were carefully sunk through the foundation rock of five of the buttresses to a depth of 30ft so as to check the extent and disposition of the clay seams. These pits were thereafter filled with concrete. The excavation work also includes a cut-off trench in the moraine on the right bank, and a transverse trench, built at the end of the right-hand gravity section, to stabilise the slope there, which consists of moraine.

During construction the Errochty water was diverted over the footings of one of the non-spillway buttresses, which was left low for that purpose. Some time before impounding was started (impounding up to an intermediate level was called for before the dam was complete) the river was again diverted, through the central draw-off culvert of the dam, to allow the last buttress to be completed. Apart from the draw-off culvert, which is 6ft in diameter and has a needle valve and jet disperser, there is a free overfall spillway, formed by widening out the tails of adjacent buttresses to form a continuous surface (see Fig. 8). There is a spillway channel and sill at the toe of the dam, which acts as a stilling pool. There is also a piped outlet for compensation water.

(*To be continued*)

‖ "Quality Control for Mass Concrete with Special Reference to Dams and Related Hydraulic Structures," by William Dick. Paper No. 18, Symposium on Mix Design and Quality Control of Concrete. Cement and Concrete Association, London, May, 1954.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1

LIGHT GAUGE COPPER TUBES FOR WATER, GAS AND SANITATION

No. 659 : 1955. Price 2s. 6d. This is a revised edition of the Standard first issued in 1936, and revised in 1944. B.S. 659 provides for tubes for the same applications as those covered by the previous edition, namely, tubes for water, gas and sanitation suitable for connection by compression fittings or capillary fittings, or by bronze or autogenous welding. The 1936 specification standardised the tubes on the basis of the outside diameter. The 1944 revision effected a reduction in the thicknesses of the tubes. A separate table of dimensions was also included for tubes for sanitation which permitted, for the nominal sizes 2in and upwards, thinner wall thicknesses than those specified for water and gas. The outside diameters established in the first issue were retained in both tables in order to avoid disturbance of the existing ranges of fittings for connecting the tubes. A closer tolerance was specified on certain of the outside diameters. In this revision the method of designating tubes has been retained, but that of expressing tolerances has been clarified ; additional sizes, viz., 5in and 6in have been included. The value of the tensile strength has been reduced from 17 to 16½ tons per square inch. Other amendments are the introduction of a weight clause and a new method of marking the tubes.

British Association Meeting at Bristol

No. I

THE 117th annual meeting opened at Bristol on Wednesday evening of last week, under the presidency of Sir Robert Robinson, O.M., F.R.S. Prior to the opening session in the Colston Hall, the Vice-Chancellor of Bristol University, Sir Philip Morris, conferred the D.Sc. degree on Sir Robert Robinson and on Professor N. F. Mott, Cavendish Professor of Physics at Cambridge University. Sir Robert Robinson then delivered his presidential address entitled "Science and the Scientist." Extracts from this address were printed in our last issue.

The sectional meetings began on Thursday morning of last week. The president of Section G., Engineering, is Dr. S. F. Dorey, F.R.S., and his address (which was abstracted in our last issue) was entitled "The Influence of the Engineer on Sea Transport and Trade."

One of the papers presented in Section G on Thursday morning, following the presidential address, was by Mr. Milton W. Rosen (Naval Research Laboratory, Washington), and was entitled "Influence of Space Flight on Engineering and Science." In this paper, Mr. Rosen recalled that within the last few years many scientists had predicted seriously and confidently that human beings from the earth would, in the foreseeable future, travel to the moon and the nearer planets. Although much of the progress was still guarded by military necessity, space flight was emerging as an activity in its own right, one that could command the effort of many engineers and scientists.

In the United States, Mr. Rosen said, the exploration of the upper atmosphere was a vigorous and continuing activity. Pilots of rocket aircraft had experienced conditions approximating those in free space, if only for a few minutes, and the effect of space flight upon the human organism was being investigated.

Mr. Rosen concluded his paper by saying that prior to establishing the first manned satellite two important techniques would have to be mastered. First, there would be a period of experiment with unmanned, instrumented satellites during which time problems of propulsion, staging, and navigational control would be worked out. The environmental hazards—cosmic radiation, meteors, solar heat (and the absence of it), and possibly weightlessness—could be evaluated. The second problem was the one of safe return to the earth's surface. The relative speed of roughly 5 miles per second between the orbiting vehicle and the earth's surface must be brought to zero. Although space flight was yet to be achieved, its prospect had had, in the last fifty years, an appreciable influence upon science. The advances in our technology necessary to achieve manned flight in space and those required to exploit it could be readily delineated, but a more important result would be the impact of space flight upon scientific thought and education.

On Friday morning, the meeting of Section G divided into two groups. In the first group there were papers on "Model Research and its Application to Ship Design," by Dr. R. W. L. Gawn, and on "The Scientific Development of Modern Locomotive Designs," by Mr. J. S. Tritton and Mr. J. C. C. Paterson.

In the second group there was a lecture, by Dr. J. V. Dunworth, of the United Kingdom Atomic Energy Authority, entitled "The Methods of Using Fuel in a Nuclear Reactor."

In this lecture, he discussed the various kinds of reactor which might be built and the various ways of using nuclear fuels in a nuclear power programme. Dr. Dunworth pointed out that a nuclear reaction contained fuel; it might contain a fertile reactor, and it did not need anything else. An atomic bomb, which was a reactor out of control, simply contained fissile material only. In order to control the reaction, one put in additional materials which absorbed neutrons and stopped the reaction. If there was only fuel in a reactor and nothing else, one had a fast reactor, because the neutrons which kept the chain reaction going were born at a very high velocity and were used right away. If, however, there was put into a reactor a conditioned material called a moderator which slowed down the neutrons, the neutrons were not used after they were born until they were slowed down. A pile consisted of a fuel, a moderator, a controlling rod and a fertile material. If the reactor was not to melt, a coolant was required and a tube to contain the coolant. In addition, the reactor was an intense source of radiation, and therefore the reacting core was surrounded with 6ft or 7ft of concrete. In theory there were hundreds of ways in which a pile could be built, and the crucial test was the economic one.

Dr. Dunworth then described how a nuclear energy programme was started. The natural uranium having been dug from the ground in the form of ore and purified, there were then two things that could be done to it. Natural uranium contained two types of uranium, 235 and 238. U235 was a natural fuel which occurred to the extent of one part in 140. U238 atoms could be used for making fresh fuel if they were placed in a pile. One thing that could be done was to separate these two types of atom in order to get pure fuel atoms free of U238 atoms. Since the two atoms were alike chemically, it was necessary to work on some process other than a straight chemical one, and the most economical plant which had so far been built was a diffusion plant. To give an idea of the scale of operation in this field, America had built diffusion plants which used almost as much electricity for this purpose as the entire consumption of electricity in Great Britain. The other thing that could be done with natural uranium was to put it into a pile which was capable of working with natural uranium. Out of the tremendous number of possible piles, there were only two which were likely to work at all economically with natural uranium. One used graphite as a moderator and gas for cooling, examples being BEPO at Harwell, the Windscale plant and the new Calder Hall generator station. The other kind of pile that was possible was one that was cooled and moderated with heavy water under pressure. With a pile which worked on natural uranium, pure fuel was produced, because the U238 in it was converted into plutonium, which was a pure fuel, just as U235 was. As soon as one had got pure fuel the way was open to tackle the question of the very large number of different kinds of piles. This was the very interesting stage which had been reached in this country. A great deal of thought had been given to what should be done with the pure fuel which was to be made. A small fast reactor had been built at Harwell and a large fast reactor was being built at Dounreay. So far the Authority had made no announcement about what it was going to do in the thermal reactor field. For thermal reactors there were four moderating atoms: beryllium, carbon, heavy hydrogen, and light hydrogen; and for early use the state of development and the time scale were such that it was necessary to limit the coolants to gas, heavy water, light water and sodium. It had been decided in the thermal field to start with gas cooling and carbon, with the possibility of sodium cooling.

In reply to questions and comments, Dr. Dunworth said that in the unlikely event of a reactor becoming completely out of control not very much would happen. It would melt a bit of the inside. Although it was very unlikely to happen, as a last line of defence a large container could be put round it, as at Dounreay. He did not think there was any serious public health hazard from the waste products. With a well-managed project there was no reason why any waste should leave the factory. The room in which he was speaking (a hall about 100ft by 40ft) would contain the waste products of supplying the whole country with electricity for 100 years or more.

One speaker commented that he was concerned about the effect which the present very large amount of publicity with regard to atomic energy would have on the distribution of scientific talent of the younger generation. Might not the effect be that too many of the young men would turn their attention towards turning the atomic energy into heat and nobody would concern himself with the electricity coming out at the other end?

In reply to a question about the life of reactor equipment, Dr. Dunworth said that there was no doubt that reactors could have a very long life indeed—comparable with that of normal power plants. A technique of maintenance was rapidly being learned which should give the equipment an indefinite life, the limiting factor being obsolescence.

To a question about the kind of men who would be required to work on atomic energy, Dr. Dunworth replied that atomic energy had been surrounded with an aura of mystery and secrecy, but it was quite an ordinary subject. He did not think it would ever be "pure conventional engineering" but would always have a very strong scientific flavour, and he considered that a great deal of it would be in the tradition of chemical and aeronautical engineering as distinct from the older branches of engineering viewed narrowly. Success would go to a considerable extent to the men who combined brilliant science with engineering. Research and development work on reactors followed the pattern of building oil refineries rather than bridge building.

Power-Producing Reactors

Mr. H. H. Gott, also of the United Kingdom Atomic Energy Authority, then gave a lecture on "The Design and Operation of Power-Producing Reactors," in which he discussed the problems met by the engineer in designing a typical reactor and outlined some of the subject matter that went into the decisions that had to be taken on various points in design. He said that what was involved was really the building of a complete new industry in this country. Over the last 100 years the engineer's job had been getting more and more complex. At the beginning of this century the engineer had had to start dealing with chemists, and more recently he had had to deal not only with chemists but with metallurgists and physicists. This had greatly affected engineering thinking, and many of the engineers inside the atomic energy project at present were often thought of as physicists and metallurgists by people outside.

A reactor of the Calder Hall type, Mr. Gott continued, contained natural uranium. In designing the reactor there were a number of fuel elements spaced apart in the moderator. Some thousands of rods went right through the moderator, each rod being surrounded by cooling channels through which the coolant passed. Questions that had to be decided were: what diameter the rods should be, how far apart they should be, what diameter or shape the cooling channels should be, and—in order to get from those rods the very large amount of heat which was generated—should extended surfaces be put on the uranium rod to improve the cooling? From the heat transfer point of view it paid to put a good deal of extended surface on the uranium rods, but, of course, uranium was far from being the only material in the reactor which was capable of absorbing neutrons, and if very much heat transfer surface was put on a heavy price was paid in neutron absorption and it was quite easy to arrive at a result which was very unfavourable.

The problem of power production, Mr. Gott observed, was not simply that of extracting heat from the reactor; it was necessary to get the heat out at as high a temperature as one conveniently could. To decrease the power used in circulating the coolant meant increasing the diameter of the cooling channels, thereby reducing the velocity of gas over the fuel elements. However, if this were done, there was the risk of decreasing the temperature rise in the reactor, and clearly once a decision had been taken on the maximum temperature that could be tolerated, the reactor must be run in such a way as to get the coolant out at the maximum temperature consistent with economic pumping of the coolant round the circuit. The sort of thermal efficiency one thought about plants of this sort was of the order of 25 to 30 per cent before subtracting the power required for the blowers. The power

consumption for the blowers would reduce the efficiency by something like 5 per cent, so that it was by no means an insignificant item in the economics of the whole plant.

Having done these calculations on the nuclear side, the results could be expressed either in terms of the number of spare neutrons produced in any one generation from, say, 100 neutrons in the previous generation—a sort of potential rate of increase of neutron population in the reactor—or in terms of the critical size which was necessary to make the reactor operate at all, or in terms of concentration of U235 which was necessary to make a reactor of a given size work. It was not sensible, of course, to build a reactor at exactly the critical size. The reactivity of the pile was sensitive to neutron temperature, and this would mean in practice that if one built a reactor of just the critical size at running temperature, it would not be critical and it would not work at a higher temperature. It was also necessary to allow for the absorption of neutrons in poisons which were produced during the fission process. Moreover, in a reactor of about critical size there would be a very uneven neutron flux distribution across the reactor, with a consequential marked peak in the neutron flux and therefore the heat generation through the reactor. It was desirable to increase the size of the reactor over critical and to insert a neutron absorbing material, and in order to be economic it was necessary to make sure that the neutrons which were being absorbed in this way were employed usefully in the production of new fissile material.

The problem of deciding the maximum temperature at which the reactor could be operated was similar to the problem met with in, for instance, designing gas turbines, where one had to decide the temperature at which the blade could be run. It might in the case of a reactor depend on the melting or softening point of the material used for shielding the uranium or on the very high temperature gradients which existed in the uranium itself, which might mean that some parts of the uranium would operate molten. If there were a uranium rod with a very high rate of heat generation inside it, there would be quite a steep parabolic temperature distribution inside the rod. In doing calculations it was necessary to reckon that there would be a considerable change—usually detrimental—in the physical properties of the materials during their time in the pile. The other thing which might occur was that the graphite would be heated up by the neutrons which were wandering round inside it and losing energy to it. The graphite was being cooled by a gas and one had to consider at what temperature the rate of oxidation of graphite was an acceptable one and at what temperature the moderator would be burned out of the pile more rapidly than could be tolerated.

Another problem which had to be dealt with was the necessity for shielding the reactor. The neutron flux inside the reactor was so high that if there were no shield round it, one could not approach within a very considerable distance—tens of miles. Even though a reactor of the kind now under consideration operated on thermal neutrons, there was still quite a considerable proportion of neutrons which would leak from it which were fast neutrons, and since these were quite difficult to capture to the extent which was necessary, it was essential to slow them down in the shield before they were captured. To do this, the reactor was surrounded with a moderator. The cheapest way of doing this when a high neutron absorption was wanted was to use water as it was contained in concrete. The reactors were therefore surrounded by shields of concrete about 7ft thick. Each 6in of that thickness would decrease the neutron flux by a factor of 10 per cent. The concrete was protected from the high neutron flux with something like 6in of steel or cast iron which absorbed more than 90 per cent of the neutrons and gamma radiation which came from the reactor. It was quite an interesting problem, if one wanted to make a hole through a shield of this sort, just what sort of gap could be allowed—how many neutrons and what gamma radiation would come through it. In moderating and capturing neutrons in the shields, gamma rays were produced and quite an appreciable part of the shield towards the outside was really occupied in absorbing the gamma radiation which had been emitted within the shield itself from the neutrons absorbed in it. It was sometimes convenient to consider using boron to absorb the neutrons or to use a very high density concrete which was much better in absorbing gamma radiation than was the conventional concrete.

Mr. Gott added that other engineering problems of a slightly more orthodox nature were, for example, whether or not the fuel elements should lie vertically or horizontally; whether the graphite structure, which was a most elaborate affair of graphite blocks machined to very close tolerances, was more conveniently arranged for a pressure vessel which had its axis horizontal or its axis vertical; and whether the thermal aspects of the duct work were more conveniently accommodated one way or the other.

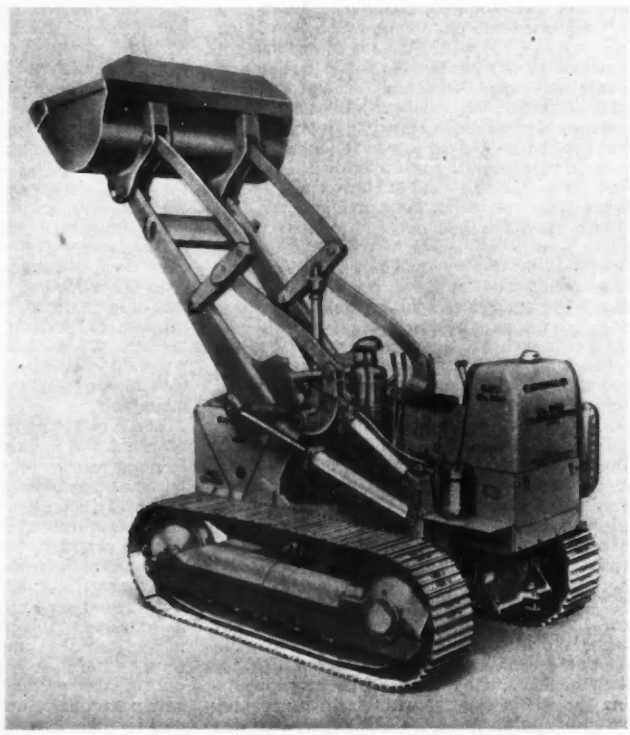
At the conclusion of the meeting, members attended the first showing in this country of the colour film entitled "Calder Hall."

(To be continued)

Tractor Shovel

A TRACTOR shovel known as the No. 955 "Traxcavator," fitted with a 1½ cubic yard bucket, has been added to the Caterpillar range. The unit has parts in common with the "D.4" tractor, but the shovel mechanism is built on to a rigid frame which relieves the transmission casting of additional loads. The hydraulic system and rams are at the rear of the machine in order to balance the weight of bucket and load: a full-flow hydraulic oil filter is provided. The bucket has hardened steel pads to protect the arm ends and replaceable cutting edge; it rocks backward 40 deg., part of its weight being transferred to rests on the main arms. Depth of cut and angle of attack can be controlled while the tractor is moving into the job.

The engine gives 70 b.h.p. with a maximum forward speed of about 7 m.p.h., and can be directly started by a 24V motor or fitted with an auxiliary petrol engine. The complete excavator weighs nearly 9 tons 12 cwt., and is illustrated herewith.



Hydraulically-operated loading shovel: the action of the lift and tilt rams can be seen

International Union of Producers and Distributors of Electricity

THE Tenth Congress of UNIPEDE (l'Union Internationale des Producteurs et Distributeurs d'Energie Electrique), will open in London on Monday, 19th September, under the presidency of Lord Citrine, Chairman of the Central Electricity Authority. It will be recalled that UNIPEDE, which has its permanent secretariat in Paris, is an association of organisations representing the interests of producers and distributors of electricity in each member country. It is concerned with general economic and engineering problems of electricity supply and with international transfers of electricity and the compilation of international statistics. The Congress meets every third year in one of the European capitals and this is the first time it has met in London. It is anticipated that the total number of delegates and visitors will exceed 1000, representing the interests of producers and distributors of electricity in the principal European countries.

The proceedings will begin on Monday morning 19th September, at the Central Hall, Westminster, where the delegates and their wives will be welcomed by Lord Citrine and Councillor Patrick Stirling, the Mayor of Westminster. The Rt. Hon. Geoffrey Lloyd, Minister of Fuel and Power, will then open the first session of the Congress at which an address will be given by Sir Christopher Hinton, Managing Director of the industrial group of the United Kingdom Atomic Energy Authority. On Monday evening there will be a reception attended by the Lord Mayor at the Guildhall.

The working sessions of the Congress, lasting four days, will be held at Church House, Westminster, and will be devoted to the presentation and discussion of several papers covering thermal and hydro-electric generation, atmospheric pollution, distribution, tariffs, statistics, and protection of telecommunications. Three study tours in England and two in Scotland have been arranged for the delegates, who, in separate parties, will visit places of technical interest including steam and hydro-electric power stations, substations and distribution installations and places of general historical interest. Visits have also been planned to other places of electrical and general interest, in and around London, including the Central Electricity Authority's Research Laboratories at Leatherhead.

Steam Economy at Power Stations

MANY suggestions have been put forward in the past that the Central Electricity Authority should make greater use of the possibilities of the economies resulting from the simultaneous supply of steam and electric power from a power station. Upon investigation most of the schemes put forward have proved for a variety of reasons to be uneconomic. However, a detailed study of a scheme involving the British Celanese Works at Spondon, near Derby, has shown that the circumstances of the supply are highly favourable, and the Central Electricity Authority has announced that an agreement has been completed between it and British Celanese, Ltd., for the supply of steam from the Authority's Spondon power station to the company's works. The works and the power station are on adjoining sites, so that only a short delivery system will be required and the provision of the steam supply will allow British Celanese, Ltd., to dispense with

some less efficient low-pressure boiler capacity. Although the steam used at the works will be at the relatively low pressure of 160 lb per square inch, it will be generated at over 900 lb per square inch and reduced in pressure through special back-pressure turbines to produce electricity at high thermal efficiency. This combined production of steam for industry and electricity is estimated to effect an overall saving of 100,000 tons of coal per annum, which is considered sufficient justification for the project.

African Engineering News

BY OUR SOUTH AFRICAN CORRESPONDENT

Diesel-Electric Locomotives for Southern Rhodesia

Twenty-three diesel-electric locomotives are being built by the English Electric Company, Ltd., for the 170-mile section of the railway between Salisbury and Urntali. It is stated that they will be the most powerful single-unit engines yet designed for a narrow gauge line. The Salisbury-Urntali section is one which, with its gradients, curves, a high altitude exceeding 5000ft, and high temperatures provides the most exacting conditions for railway operation with diesel motive power.

The locomotives are "semi-streamlined" and the driver and assistant are provided with fully adjustable upholstered seats. Warning lights indicate wheel slip, blower motor failure, low oil pressure and high water temperature. To ensure smooth riding and quiet operation the power unit as a whole is mounted on a four-point resilient suspension, and roller bearing axle boxes are fitted throughout. For the heavy haulage and steep gradients of the Rhodesia Railways, the locomotives are being fitted with air brakes which can be separately controlled. The underframe is an all-welded steel structure incorporating a 1000-gallon fuel tank.

Great things are expected from the introduction of these new 2000 h.p. locomotives and it is hoped that they will enable the railways to overcome their present shortage of power. They are expected to contribute considerably to the net revenue of the railways because of their economical performance. The introduction of these units indicates a major change in railway policy, though it does not mean that steam locomotives are to be abandoned. The first of the new engines has been handed over for service, and all twenty-three are expected by February, 1956.

First Railway Tunnel in Rhodesia

Another chapter in the history of the Rhodesia Railways has been completed and the first tunnel on the system has become an accomplished fact. Situated on the new Wankie avoiding line between Mbarira and Thomson Junction, the tunnel is slightly in excess of 277 yards in length and was completed four months ahead of schedule. The new avoiding line on which the tunnel is situated is being laid down to take the main line over terrain that is not likely to be affected at any future date by any underground mine workings. It is approximately 2 miles longer than the existing track and it bypasses Wankie. It leaves the existing track at Mbarira and rejoins it again at Thomson Junction. Since the old line will be left intact, however, local traffic from the colliery town will still retain a link with the main line to the north at Thomson Junction and to the south at Mbarira.

Although only some 8 miles in length, the avoiding line with its tunnel can be considered a project of major importance. The ruling grade is 1 in 120 and apart from the tunnel itself, it includes one two-span bridge and a number of minor culverts. In June this year all culverts and approximately 90 per cent of the earthworks had been completed, although no track laying had been started. The tunnel was driven through a hillside of shale. The approach cuttings are largely of sandstone, but the tunnel itself goes through black shale, the contractors actually striking a number of thin seams of coal which they promptly used to fire their forges! Altogether some 17,000 cubic yards of earth had to be removed in the approach cuttings, 12,000 cubic yards in the tunnel and an additional 1000 cubic yards in the portals. More than 3300 cubic yards of concrete were used. Five Europeans built the tunnel with a labour force of some 120 Africans.

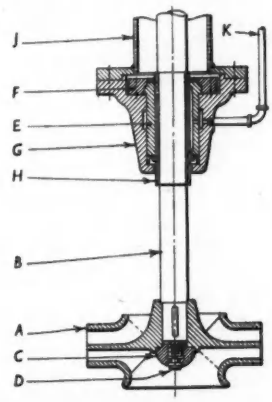
Railway Development in the Orange Free State

A comprehensive programme of railway development is at present being tackled in the gold-fields and Northern Free State area. It is considered that it may become necessary to operate diesel-electric rail coaches between the Rand Free State gold-fields and possibly Bloemfontein, the coaches envisaged being of the streamlined design in use overseas. A technical committee set up by the South African Railways and Harbours is at present investigating three important aspects of rail transport. These are: how far electrification should be extended; how far steam should be further employed; and should diesel-electric traction be employed?

Continental Engineering News

Centrifugal Mixer

A centrifugal mixer, of which the impeller and front bearing are shown in the accompanying diagram, is being put on the market by Rheinhuette vormals Ludwig Beck and Co., Wiesbaden-Biebrich, Rheingaustrasse 30, German Federal Republic. The mixer is intended for the stirring of liquids of up to about 3000 centipoises, slurries and emulsions. As illustrated here, the impeller *A* consists of a double-sided casting having two vanes in each half. This is fitted to the shaft *B* by the nut *C* and locking screw *D*. The shaft runs in a front bearing *E*, retained in its housing *G* by the ring *F*. The drive, not shown here, is direct through a flexible coupling, with the other end of the shaft fitted with ball and thrust bearings. Sleeves *H* are provided for the journals, and a shaft tube *J* connects the front and rear bearing housings. For shaft lengths above 6ft an intermediate plain bearing is fitted. Lubrication can be from the fluid in the tank, or with water or grease. The rear housing, which carries the motor, is flanged with the shaft passing through a stuffing-box in the flange. Various forms and sizes of impeller are available, depending upon the application and the shape and size of the tank, and exposed parts are constructed of corrosion-resisting alloys. The stuffing-box or mechanical seal and the lip seal shown permit the tank to be used at pressures above atmospheric. For the addition of gases or liquids to the mixture, feed pipes may be run which open under the impeller intake. The mixer can also be used for degreasing. It is stated that successful tests have been performed with, among other things, water and iron filings, water and oil, gypsum slurry, high viscosity lacquers, air and gas admixture to various liquids, and with cellulose and paper-pulp masses of high concentrations (4 to 5 per cent).



Section of double-sided impeller and front bearing of centrifugal mixer for liquids

Rationalisation in the German Industry

Increased measures of rationalisation will be needed to offset shortages of labour in many branches of industry, according to Dr. Kurt Magnus, of the German Rationalisation Board (Rationalisierungs-Kuratorium der Deutschen Wirtschaft, RKW). Skilled labour in particular would become increasingly scarce owing to the reduced intake due to the low birth-rate of the war years. By 1956 the number of apprentices available for specialised training would be only about two-thirds. The German defence contribution would also reduce the available industrial manpower to some extent.

The first step undertaken by German industry had been to make the process of production less complicated and less expensive. Efforts to increase productivity were being made by a number of groups, all of which interchanged their experience and findings. The general trend was to reduce variety and to stress mass production. An example was the radio industry, where in 1950 there were 450 different types of sets on the market. One year later this number had been reduced to 280. Instead of 200 different kinds of copybooks for school children there would in the future be only eleven. In the construction industry a committee of the Standards Institution (Deutscher Normenausschuss) was studying the question of standardising building parts. Standard sizes for such things as windows, doors, bricks, tiles, locks, and pipes could lead to savings of up to 40 per cent.

As for marketing, it was well known that the cost of distribution often amounted to one-half to two-thirds of the retail price. The entire marketing procedure would have to be rationalised all the way from market research, which should precede production, to questions of choosing sales personnel, advertising, correspondence, and service.

It was only more recently, said Dr. Magnus, that it was realised in Germany that rationalisation could be applied to the human aspects of industry. Studies are now becoming more and more numerous which deal with problems of human relations in the factory, while other work was concerned with improving the workers' environment and thereby increasing efficiency and reducing fatigue.

The RKW was formed in 1950 as successor to the Reichskuratorium für Wirtschaft-Lichkeit in Industrie und Handwerk (founded in 1921). It promotes and co-ordinates the work of all rationalisation groups and maintains an inquiry service, which has dealt with 10,700 inquiries since 1950. The twelve RKW groups are those concerned with construction, documentation, utilisation of electricity, commerce, crafts, housekeeping, industrial distribution, human relations, shipbuilding, standardising, packing, and transportation.

Other agencies which concern themselves with rationalisation as part of their work are the regional groups of the Federation of German Industries (Bundesverwaltung der Deutschen Industrie, BDI), and the chambers of trade, commerce and crafts.

Technology of Mechanical Transmission

The Verein Deutscher Ingenieure (V.D.I.), together with the Verein Deutscher Maschinenbau-Anstalten (V.D.M.A.), and the mechanical transmission section of the Ausschuss für Wirtschaftliche Fertigung (A.W.F.), will hold a congress at the Rheinische Ingenieurschule, Bingen (Rhein), from September 29 to October 1, 1955, on the subject of modern developments in the field of mechanical transmission. Lectures, to be followed by discussions will be given dealing with non-uniform gears and plane and space link mechanisms. The talks will be based on the results of research, design experience, and methods of calculation, and will be illustrated by many examples of successful practical applications. There will also be a session of practical exercises for designers, and a number of social events. A large collection of models will be on view in the premises of the Rheinische Ingenieur-Schule. Applications for admission (fee, DM.25) should be sent before September 24, 1955, to Verein Deutscher Ingenieure, Abteilung FG, Düsseldorf, Prinz-Georg-Strasse 77/79.

Industrial and Labour Notes

T.U.C. Presidential Address

The annual assembly of the Trades Union Congress opened at Southport on Monday last. In the morning, Mr. C. J. Geddes delivered his presidential address which was entitled "How to Face the Future." In it, he said that the trade union movement must be "on guard against possible political developments designed to save the economic fabric of the country by ways which would place the burden of sacrifice almost entirely on the shoulders of the workers."

In elaboration of his comments on the economic situation, Mr. Geddes suggested that the T.U.C. should prepare an economic survey of the post-war years and "draw conclusions for the future." This survey, he urged, should be examined by the general council, and should then be considered by a special conference of union executives with a view to the formulation of a national trade union economic policy. Mr. Geddes went on to mention that the Chancellor of the Exchequer had blamed strikes as one cause of the deterioration in the economic situation. Trade unionists might resent that suggestion as an excuse for Government failure, but the truth of the assertion could not be denied that strikes might well have been a contributory factor. If the need for rising production was accepted, Mr. Geddes asserted, then not only the cost but the means of production must be considered. Any disturbance in the even flow from the production lines must be considered. Trade unionists could not, and should not, try to abolish strikes, but they should and must remove as many causes for them as possible, and adequate arbitration machinery, Mr. Geddes suggested, would appear to be the means by which most of the causes could be very greatly reduced. But if arbitration was to be really effective, it must meet certain conditions and conform to certain standards. It must be impartial; it was not entitled to assume the role of wage fixer or wage regulator and by that means to impose unacceptable collective agreements of its own design.

Mr. Geddes went on to say that arbitration was so much a part of British industry that an "industrial judiciary" had been created with powers which were greater than those of the legal judiciary. He wondered if it was not time that "this vital part of the industrial machine" was overhauled? If arbitration was to be truly effective, Mr. Geddes declared, trade unionists must prefer to use it rather than to take strike action. He felt, however that, consideration should be given to the setting up of an Arbitration Appeal Tribunal where both sides could seek a second opinion. Consideration clearly was necessary, Mr. Geddes added, for such a body could be abused by both sides. Its use could lead to deferment of the application of awards or to frivolous and spiteful appeals, but were those obvious disadvantages greater than the present ones which permitted decisions, often affecting millions of workers, to be made behind locked doors, and against which there was no appeal but a strike? If strikes were to be prevented, an effective and acceptable alternative must be provided. Despite this country's long experience of arbitration, Mr. Geddes commented, it was by no means certain that it was so efficient and so effective that strikes could no longer be justified.

At this point in his address. Mr. Geddes stressed that an improvement in the arbitration machinery was not of itself the only and complete answer to the prevention of strikes; there must be a change in the attitude towards industrial disputes. He wondered if there was not an inclination to ignore the material change which had taken place in industrial relations. Surely it was true, Mr. Geddes said, that whereas fifty years ago employers generally were determined not to reach agreement, they were now anxious to do so. It was "in their interests that they should," he claimed, for a strike to-day meant not only loss of wages to the worker but loss of trade and profit to the employer. In those circumstances, Mr. Geddes urged, it should surely be possible to prevent or at least reduce interference with the even running of our industrial life which, in the long run, affected the workers more materially than it did the employer.

Average Earnings of Manual Workers

The Ministry of Labour has issued some provisional figures derived from a survey, which it made in the last pay week of April, of the average earnings of about 7,000,000 manual workers in the manufacturing and some of the principal non-manufacturing industries in the United Kingdom. These figures show that the average earnings of all manual workers in all the industries examined, inclusive of bonuses and overtime, and before the deduction of income tax or insurance, amounted to £9 2s. 3d. This compares with an average of £8 11s. 9d. in the last pay week of October, 1954, and £2 13s. 3d. in October, 1938, the percentage increases thus being 6 per cent and 242 per cent respectively.

The Ministry says that, compared with April, 1947, the average level of weekly earnings showed a rise of about 76 per cent at April, 1955, the corresponding figure at the end of October, 1954, being 66 per cent. From the index of wage rates, as distinct from weekly earnings, it is estimated that, in the industries covered by the inquiry, the average level of rates of wages in April last was about 52 per cent higher than in April, 1947, compared with 45 per cent at the end of October, 1954. For men only (twenty-one and over) the average weekly earnings in the last pay week of April, 1955, were £10 17s. 5d., compared with £10 4s. 5d., in October, 1954, and £3 9s. in October, 1938. The average weekly earnings of men in the manufacturing industries alone were £11 4s. 7d. in April, 1955, compared with £10 12s. 3d. in October, 1954.

In all the industries included in the survey, the average hours put in by all manual workers in the last pay week in April were 46·9, compared with 46·7 hours in October, 1954, and 46·5 hours in October, 1938. In the manufacturing industries only, the average hours worked in the week examined were 48·9, compared with 48·5 hours in October, 1954, and 47·7 hours in October, 1938.

Science and Management

The British Institute of Management has issued the programme of its national conference which is to be held at Harrogate from November 2nd to 4th. The general theme for the conference is "The Impact of Science on Management in the Future." Throughout the conference, the programme says, stress will be laid on the need to translate new scientific discoveries into practical day-to-day effect.

"Automation" is one of the new techniques to be discussed at a sectional meeting of the conference. Other subjects include the uses of radio-active isotopes and the electronic processing of data, while a panel representing scientists in industry will discuss changes brought about by recently developed materials and processes. The application of scientific techniques to retailing and market analysis is to be studied at the conference and the contributions of such sciences as sociology and economics. Special attention will be given to the human aspects of technological progress and to the problems of training managers to meet the needs of the future.

Full details of the conference are available from the British Institute of Management, 8, Hill Street, London, W.1.

Industrial Accident Prevention

The Royal Society for the Prevention of Accidents has announced that a conference on industrial accident prevention is to be held at Guildhall, London, on Friday, October 28th. It will be opened by the Lord Mayor of London, and is to be addressed by the Minister of Labour, Sir Walter Monckton, Q.C.

At this conference, Sir Ewart Smith, chairman of the British Productivity Council, will speak on "Accident Prevention and Productivity," Mr. A. E. Amor, deputy managing director of Kodak, Ltd., on "Accident Prevention and Manpower," and Mr. P. E. Trench, managing director of Bovis, Ltd., on "Accident Prevention and Efficiency," making particular reference to the building industry.

The conference is being organised by the London industrial co-ordinating committee, which represents five industrial accident prevention groups working in and around London. It is stated that the conference is the principal event of a "National Industrial Safety Week," during which a campaign for safer working in British industry is to be launched. The object of the campaign is to encourage all workers, and especially young workers, to "start a safety habit to-day" and to remember that "safety habits last a lifetime." It is hoped to introduce both these slogans into every factory throughout the United Kingdom. Another object of the campaign is to bring into the voluntary safety movement a great number of the smaller industrial concerns which at present have little or no safety organisation in their factories.

It should be added that the conference on October 28th is open to anyone interested in industrial accident prevention. Admission tickets (at 10s. 6d. each) may be obtained from Mr. H. Meanley, North Thames Gas Board, Kings Road, Fulham, S.W.6.

Coal

Some observations on this country's coal situation are made by Sir Herbert Merrett, chairman of Powell Duffryn, Ltd., in a statement included in the company's annual report and accounts. Sir Herbert says that, although coal bunkering at home and abroad has fallen in volume to a mere fraction of prewar figures, there remains at the moment a considerable demand for British coal from overseas countries and old established markets, which unfortunately cannot be met. Prices obtainable in most of these markets, Sir Herbert claims, are more than five times greater than prewar realisations. Even more unfortunate, the statement continues, is the necessity to step up the import of foreign coals for consumption in this country. It is nothing short of a tragedy, Sir Herbert considers, that Great Britain has now become a net importer of solid fuel and is likely to remain so for several years. This is gradually leading to the abandonment of Britain's overseas coal markets, he adds, and a rearrangement by overseas buyers of their sources of supply.

Sir Herbert goes on to stress that, in the absence of current supplies of British coal, our foreign trade must progressively diminish and may be non-existent by the time British coal output is stepped up or a surplus becomes available for reasons of reduced industrial demand at home. But, Sir Herbert points out, it is only fair to say that coal consumption, despite the increase in the use of liquid fuel, is at a higher level now than ever before in the country's history. Notwithstanding the great increase in prices, there appears yet to be little economic attraction in converting from solid to liquid fuel, but, the statement emphasises, the time is rapidly approaching when liquid fuel will have to be used in greater quantities, especially in nationalised industries. Sir Herbert's final comment is that what surprises him to-day is the slow progress which has been made in this country in the more efficient use of solid fuel. He points out that "it has been asserted with great confidence by combustion experts that a large percentage of our imported coal would become unnecessary if advice on modernisation were sought and adopted."

Continuous Casting Installation for Stainless and Alloy Steels

The revolutionary steel mill plant installed at the Welland Works of Atlas Steels, Ltd., in Ontario, which was described and illustrated in our issue of December 31, 1954, has now been in operation for more than six months. It is therefore of interest to review the experience obtained at these works to date, and the following account deals particularly with (a) the continuous casting process, (b) the automatic scarfing machine for use on stainless steels, (c) the Sendzimir hot planetary mill, and (d) the electrolytic salt descaling process used in the annealing and pickling line.

SEVERAL interesting pieces of steel mill equipment were recently installed at the Welland Works of Atlas Steels, Ltd., in Ontario, including a Rossi-Junghans continuous slab casting machine, a Linde powder scarfing machine, a Sendzimir planetary hot rolling mill and an electrolytic salt descaling line. According to the company, at the present time, the electrolytic salt descaling process is completely out of the development stage and in full commercial production. The other three developments have been proved to be commercially successful, but the company must yet become more proficient in their use and work some " bugs " out of the design and operations before their economic success is fully realised.

Continuous Casting

The continuous casting process resolves itself into the manipulation of a series of continually changing conditions to achieve a constant result. The tapping and ladle temperatures are key points in this operation and because they are variable the user is faced with a variable starting point. The firm therefore found it necessary to conduct a series of experiments to learn how to control a number of variables. At present there still are certain limitations and disadvantages in the operation : (1) The knowledge is limited and hard won. Whenever a different composition or size is to be cast, all data must be collected through operations. Therefore, earlier savings are constantly being reinvested in experiments. (2) The size of the section is limited as yet, but this will quickly disappear, particularly for slabs. (3) Speeds and methods of cutting off the product limit production. (4) Until a shop is designed around the continuous casting machine, the melting shop scheduling is hard to adjust and delays result. (5) Higher temperatures and longer ladle times take their toll of ladle and furnace refractory life. (6) Some charging times in the melting shop will increase as the returned scrap to the melting shop decreases. The continuous casting machine produces billets with a very satisfactory surface. From the operations to date it has been found that good surfaces can be obtained under a very comfortable range of operating conditions. Poor surfaces result from very slow pouring into the continuous casting mould, just as they are produced in a similar way on standard ingots. One of the criticisms most often raised in connection with continuous casting is the expected non-uniformity as far as chemical composition and segregation are concerned. From the work at Atlas Steels to date, it can definitely be reported that no unusual variations in chemistry have been detected. Samples taken at intervals throughout the pouring operation for chemical evaluation indicate that there is no problem with chemical variation from the beginning to the end of the cast.

The next phase of the quality evaluation necessarily deals with the general characteristics of internal quality as shown by deep acid etching and microscopic examination. In the early stages of developing this equipment, and during the time in which operators were learning the mechanical operations and the operating factors for casting sound billets, most of the castings made were of unsuitable quality. A great deal of the material was rejected because of poor cast structure primarily due to a faulty centre. To control the as-cast quality the staff had to know what the machine does and how its behaviour is affected by changes in the operating conditions. For example, Fig. 1 summarises the present knowledge concerning the heat removed by a slab mould. It illustrates that, as the casting speed is increased, the total heat removed per pound of steel cast decreases. The implication is, of course, that the casting wall becomes thinner and/or hotter and more liable to rupture. Similar heat removal data have been gathered for the spray systems. The as-cast quality depends on and will change with the cooling conditions. It is clear, then, that for uniform quality the cooling intensity should not change.

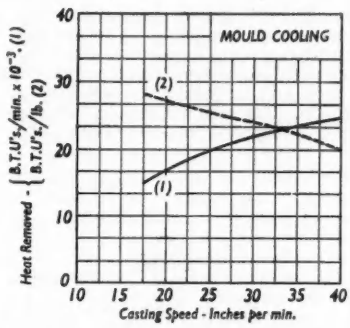


Fig. 1—Heat removal by continuous casting machine at various speeds

The most certain way to reach uniform cooling intensity is to establish constant casting speeds. This is difficult to achieve in practice. Yet it is necessary, since changes in casting speed must be accompanied by suitable changes in cooling water volumes to maintain fixed cooling conditions and quality.

The company felt that at the earlier stages of perfection of the continuous casting operation it would be wise to put some reduction on the metal in the blooming mill and to condition before going to the finishing process. It can now definitely be said that the elimination of the blooming mill entirely from the processing can develop in the future. Many experiments have been run with slabs from the continuous casting machine being rolled immediately to hot band with no prior conditioning, and the results are very promising. Regardless of whether the blooming mill stays in the picture, or if the pieces leave the continuous casting machine and go directly to a finishing mill, present plans called for a high-head furnace to be ahead of the mill and after the continuous casting machine to retain the heat available in the slab or billet. This will also abolish length limitation imposed by the use of a soaking pit and allow for the exploitation of certain inherent advantages in the continuous casting process. The present status of the continuous casting machine shows that commercial production of slabs 5½in by 21½in has been achieved in such stainless steel compositions as 17 per cent Cr—7 per cent Ni; 18 per cent Cr—8 per cent Ni, and 17 per cent Cr. Part of each month is devoted to straight experimentation on other moulds and other compositions.

Scarfing

As steel progresses through a representative specialty steel mill there is an area where it has been very difficult in the past to reduce manpower—the chipping and grinding section. Almost all of the higher alloys, such as high-speed and stainless steels, must have most of the skin ground from the billet before further processing. The scarfing machine, which has been in use in the steel industry for many years on low alloy and carbon grades of steel, has been unavailable for stainless and heat-resisting alloys because of the higher temperatures required for scarfing and the difficulty in controlling this operation at the speeds required for uninterrupted rolling. Hand scarfing has not been satisfactory because of the resultant surface. There have been attacks made on this problem by the use of travelling grinders and " Billeteers." In 1953, a new head was installed on the scarfing machine at the Welland Works for production runs. After more experimentation a successful slotted nozzle opening was arrived at with the powder nozzle having round tubes leading the powder against flat impingement discs of tungsten carbide.

In comparing the scarfing with the conventional slab grinding process it was found that there is an indicated saving of about 1·2 man-hours per ton. The metal removed by the scarfing process is about 3½ per cent. One weakness of the scarfing process is that defects left in the slab are disguised and can only be revealed by shot blasting. Therefore the company shot blasts all slabs off the mill after scarfing and, if any flaws are discovered spot grinding is applied. Experience has shown that as the nozzles become worn the surface becomes rougher. Also, if there is a failure in the water seals, resulting in water getting on the slab, it causes the scarfing machine to miss sections. There has, at times, been evidence of incomplete powder and slag removal, particularly on 4in squares which have been re-rolled on the mill following the blooming mill.

One of the discoveries which the staff made in the operation of this machine is that the slab is actually too clean when it is scarfed and a much more satisfactory surface can be produced if the slab has scale on it. The mill is now running a series of experiments in which a coating of some material is placed on the slab as it comes from the blooming mill to simulate a scale. The latest experiments were run during March using a mixture of iron powder and graphite. These mixtures were more successful in producing the smooth surface desired. Experimentation is continuing with good assurance of success.

Hot Planetary Strip Mill

Because Atlas Steels could not justify the extremely high capital expenditure necessary for conventional hot mill procedures in the rolling of strip, the firm decided to pioneer and installed the Sendzimir hot planetary mill followed by a two-high planishing stand. In approaching the mill, steel is heated in a high-head furnace 74ft 6in long. Slabs enter cold and progress through the furnace at speeds of 6ft to 10ft per minute, emerging to enter the mill at the desired temperature of 1700 deg. to 2200 deg. Fah. Slabs vary from 7ft 10in long to 34ft long and from 10in to 19½in wide. The thicknesses vary a little but generally are maintained at 2¼in to 2½in maximum.

In operating the planetary mill the work is forced into the planetary work rolls by two sets of feed rolls which are mounted in the same housing. In addition to pushing the steel, the feed rolls reduce the thickness of the slabs about ¼in each. The slabs are butted end to end so that one slab pushes the back end of its predecessor through the mill. In order to maintain alignment the slabs are centred by hydraulic centring devices through the furnace, and by a set of roller guides situated ahead of the feed rolls. Provision is made to speed up the feed rolls in order to close any gap that may occur between the slabs. The feed rolls are 17⅜in diameter, have a 28in face and are driven by 35 h.p. motors. They have a smooth finish and straight faces.

The diagram, Fig. 2, shows the basic principle of the planetary mill. The unit at Atlas Steels has rolls 3⅜in diameter by 24⅛in long surrounding a backup roll of 27in diameter with a 24in face. There are forty-eight small-diameter rolls, equally spaced about the two backup rolls, enclosed in cages which are

mounted on the backup roll necks. The backup rolls are driven in the direction of the strip travel by a 1250 h.p. synchronous motor through a gear reducer at the rate of 297½ r.p.m. The work roll cages are driven in the same direction as the backup rolls through an air clutch from the mill drive at a speed of 146 r.p.m. The difference in speed between the backup rolls and the cage assembly causes the work rolls to revolve at a speed of 1130 r.p.m. in the opposite direction to the strip travel. The cage speed has

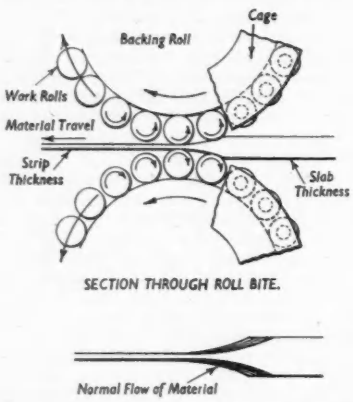


Fig. 2—Diagram of basic planetary mill principle

been found to be very critical since an increase or decrease changes the relative speed of the work rolls compared to that of the backup rolls.

The distance between successive work roll bites on a slab causes each work roll to drive and elongate a small portion of the material along the roll bite. The 2½in slab, which has been reduced to 2in through the two sets of feed rolls, is pushed against the planetary set and reduced to a thickness of about 0·1in. Because of the extreme reduction taken, the edges of the slab are rounded so that it will not " V " inward, as occurs with a straight-edge slab. Also, the first slab rolled during the day is chamfered to facilitate easy entrance into the work rolls. Experimentation has been necessary on different grades of steel to produce a proper edge. The " V " edge cools rapidly, which promotes edge cracking and tearing. Once the mill is set up for rolling to a certain gauge with the proper allowance having been made for spring, there is not too much actual operating that the mill operator can do other than to be alert for emergencies that may occur due to cobbles, &c. His most positive control is to see that the slabs are butted well in order to have the rolling operate continuously. When the last slab is through the feed roll there is no more positive pressure on the slab and the amount of metal between the roll bite and exit side of the feed roll is scrapped. At this juncture the operator opens the planetary rolls wide and allows this section to be pulled through the mill to the coiler where it is cut off.

The operation of this production planetary mill constitutes a new departure in rolling in North America. The main weakness to be overcome initially was caused by failure of the bearings on the work rolls. These are needle bearings of necessarily small size. The company found in its early rolling programme that water was getting into these bearings from the mill cooling water supply. This water corroded the bearings, causing them to seize during operations. This has now been overcome by forcing oil through the bearings after shut-down of the mill and increasing the amount of lubrication to the bearings during operations.

The company also found that the feed rolls should be hot to make quality steel and to control tracking. Heating of the solid feed rolls promoted checking and breakage. The company has put in redesigned feed rolls of sleeve design with water cooling provision for the bearings on the shafts. This change has enabled the operator to control the tracking of the slabs through the mill and prevents the chilling of the surface.

During the early stages of rolling on the planetary mill it was proved that if tension was not kept on the strip after leaving the mill buckling developed and prevented the strip from being coiled. For this reason a set of pinch rolls would be required after the mill, or the coiler would have to be placed close enough to the mill to maintain this tension. However, with the coiler placed too closely trouble would result in unloading. It was decided that, if a set of pinch rolls was needed, it would be better to place in the location of the pinch rolls a two-high mill stand capable of taking some reduction on the strip, enabling the mill to produce a 20 per cent thinner hot-rolled band. The company therefore placed a finishing mill at a distance of 9ft. centre to centre after the planetary mill. The rolls in this mill are 22½in diameter by 30in long, having composition bearings lubricated with both grease and water, and are driven by a 250 h.p. motor. A looping roll is mounted on the entry side of this mill to control the strip tension between the planetary and the finishing mill. It is operated by a separate operator, who actually has more control over the rolling than the planetary mill operator, since he can increase or decrease the speed, put tension between the mills and adjust the screws during operation.

Annealing and Pickling Line

Having decided against the use of a mechanical scale breaker, experimental work was undertaken by the firm, which resulted in the continuous electrolytic salt descaling process being adopted. Fig. 3 shows this installation diagrammatically. Two tanks are employed and both are filled with a salt—substantially sodium hydroxide with certain additions. The strip passes between negative grids in the first tank and positive grids in the second. Since the tanks are insulated from each other, the current follows the strip and maintains the efficiency of the operation. The salt is heated to 900 deg. Fah. Current is supplied at 18V, 5000A, from two

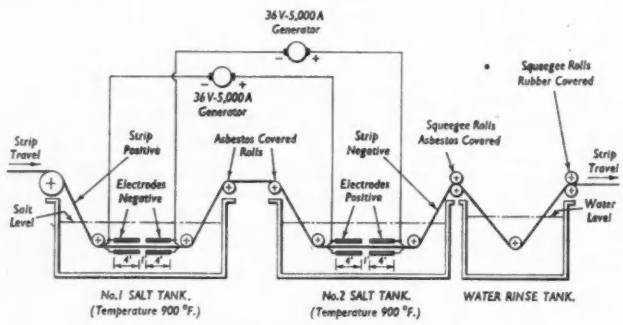


Fig. 3—Diagram of continuous electrolytic salt descaling plant for hot rolled strip, 250A per square foot

motor-generator sets only when descaling hot rolled strip. The salt alone is able to descale the cold rolled strip. On cold rolled strip, therefore, the generators are used on the nitric acid tank or the sulphuric acid tank, which are both arranged for electrolytic pickling.

Conclusions

Operation to date has indicated that the economic advantage of continuous casting can only be realised if each heat is completely tapped and cast into the desired billet. The usual measurement of this advantage is in metal yield. However, metal yield can become a very confusing yardstick unless one defines clearly what the term really means. For instance, in normal American practice, when talking yield, one usually refers to the metal recovered on the hot bed from the ingots. When attempting to evaluate the results of continuous casting one becomes aware of yield variations which caused little concern normally. Melting yield becomes a daily factor because there no longer is a " short ingot " or butt. In continuous casting, therefore, the mill reports various yields as illustrated by the following tabulation of run No. 118, heat No. 1840C on 18–8 stainless steel. The cold weight charged into the furnace was 53,377 lb. The tapped weight sent to the continuous casting machine was 51,165 lb. The melting yield was 96 per cent. The losses at the continuous casting machine were 300 lb left in the tundish, 200 lb bottom discard, 150 lb test, and a 400 lb skull in the ladle. The billets going forward to the mill weighed 50,115 lb and the casting yield was 98 per cent. The material rolled on the mill to strip and sheet slabs produced 47,450 lb, resulting in a cogging yield of 94·5 per cent. This, then, gives a yield from cold metal charged in the melting shop to billets on the hot bed of 88·9 per cent.

For several months, in order to get comparisons, the company weighed every ingot cast and determined a normal conventional melting yield of 92 per cent with from 1½ to 2 per cent of the metal remaining in the " short ingot " or butt. During this period the average weighed billet yield was 78·6 per cent, giving an overall yield of 72·5 per cent. Subsequently increased yields were obtained by using the continuous casting process because no top and bottom discards from individual ingots were required. A further increase in yields is obtainable by being able to cut billets on the continuous casting machine, which will roll to exact lengths. However, this yield increase is obtainable only if the cross section of the billet produced is kept constant. Also, as far as the melting shop is concerned, the yield loss from the last ingot cast or the butt is eliminated and this metal is saved as well.

In the operations at Atlas Steels some 250 compositions are in regular production of which as many as 150 are melted in any one month. For the first five months of 1954—using an average of all the metal cast—the pit and hot top cost involved in conventional ingot casting was about 8 dollars per ton. From preliminary operations on the continuous casting machine it has been estimated that if the works can put through about 2500 tons of metal per month the 8 dollar per ton pit and hot top cost will be equalled. During the experimental work on the machine in learning to operate it the firm was only able to use one shift a day casting on heat. In order to increase to the desired tonnage, it will be necessary to run about twenty-four heats per week. The company is now training a second operating crew in order to approach the time when the casting and pit costs will equalise.

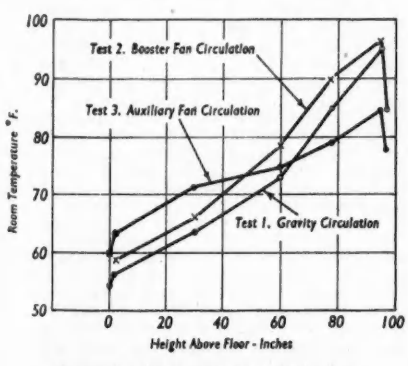
Some changes were required in the blooming mill roll designs at the Welland Works in order to produce the 19½in wide slab which the company wished to put on the Sendzimir planetary hot mill. The normal procedure in producing the 19½in by 2½in thick slab was to start out with a 22in ingot and to take thirty-two passes. With continuously cast slabs the company went to a thirteen-pass set-up, starting with the continuously cast slab at 21½in by 5½in. This led to a reduction of over 50 per cent in the actual time between the rolls and a corresponding reduction in handling, since the slabs handle more easily than the ingots.

" Package " Nuclear Power Reactor.—At the half-yearly meeting of the American Society of Mechanical Engineers a description was given in one paper of a " package " nuclear power reactor which is to be constructed by the American Locomotive Company. This plant, which will be put into operation within three or four years, was designed to comply with the need for small, special reactor plants, the component parts of which can be flown in commercial aircraft to remote places and assembled relatively quickly. Such an installation, it was stated, will cost something like 2,000,000 dollars and a plant is to be used for test purposes at Fort Belvoir. Another paper pointed out that oils and greases would not play an important part as lubricants for moving parts in the water cooled reactor section of atomic-power plants. Bearing materials that would be compatible using the cooling water as the lubricant had, therefore, to be found. The paper described many tests made on sliding, roller and ball bearings, to determine a design suitable for use in reactors.

Gravity Warm-Air Heating of Basementless Houses

AN investigation of the performance of a gas-fired wall heater installed in a basementless house has recently been completed by the National Bureau of Standards, of Washington, D.C. Sponsored by the Federal Housing Administration, the study was conducted in the Bureau's test bungalow by the heating and air conditioning laboratories of the N.B.S. The purpose of the work was to determine the temperature distribution produced in the test bungalow by a representative wall heater using either gravity circulation of the air or a small booster fan. Horizontal and vertical temperature gradients were observed as a basis for judging the acceptability of this heating system for various climates and for houses of different sizes. The observed heat loss of the test house was also compared with computed values to determine whether the capacity rating of a gravity warm air furnace should be reduced by some fixed percentage when such a furnace was situated on the living level of a one-storey house. The results now show that the heat loss of the structure was not significantly greater than for other similar heating methods where the heating unit is entirely enclosed in the heated space. It was also found that ceiling insulation is desirable to restrict heat loss upward and to promote radiation downward from the warm ceiling surface.

The test bungalow was constructed at the National Bureau of Standards for research in heat transfer phenomena. It has four rooms, a bath, and a small central hallway. Its floor area of 616 square feet approaches the lower limit of acceptable area for detached American single-family dwellings. Entire heating systems can be installed in the bungalow to obtain data for estimating the performance of these heating devices in actual dwellings. The bungalow is enclosed within an insulated enclosure so the temperature outside the house can be maintained at any level that might be encountered throughout the United States. In the present investigation the heater was situated near the centre of the house. The distance from the supply grille to the most remote doorway of a connecting room was about 11ft 6in. There was no more than one doorway between the heater and any room to be heated. Thus, the installation was favourable to good temperature distribution from the standpoint of floor area to be served, heater situation, room arrangement, and



Graph showing temperature distribution

distance from the heater to each of the connecting doorways.

The wall heater, with or without a booster fan, delivers a supply of warm air from one or more grilles whose centre lines are typically 78in to 80in above the floor level. Since practically no duct system is used, the heater can deliver warm air directly into only one, two, or three rooms, depending on the heater situation, and there may be one or more rooms that must be warmed by air movement in both directions through doorways. In the rooms heated directly by supply grilles the heated air warms the ceiling by conduction and convection ; the ceiling in turn radiates significant amounts of heat to the floor, walls and occupants of the house if the ceiling is adequately insulated. For example, in one test the average ceiling surface temperature in the living rooms was 102 deg. Fah. Previous studies of a ceiling panel heating system showed that the heat emission from the ceiling surface at that temperature was about 35 B.Th.U. per hour per square foot. Since the warmest air is near the ceiling and since the heater delivers very little warm air below the level of the top of the doorways, the air that can pass to connecting rooms through doorways is at a lower temperature and therefore conveys less heat to these rooms. There is much less radiation from the ceiling of rooms heated through connecting doorways. For example, the average ceiling temperatures of the bathroom and two bedrooms ranged from 75 deg. to 80 deg. Fah.

With gravity circulation of air through the heater none of the warm air is delivered directly to the lower half of the room. However, cooling of the room air at the exterior walls causes downward convection currents. The temperature of the lower part of the room is determined by the temperature of these downward currents except when appreciable radiation occurs from the ceiling. The air circulation rate through the heater by natural convection was between 200 and 250 cubic feet per minute—probably much less than the total natural downward convection at all the exterior walls of the house. Consequently the lower portions of the rooms could only be warmed as the downward currents of air at the exterior walls became warmer, except for radiation effects from the ceiling. Since the booster fan increased the air circulation through the heater no more than 20 to 30 per cent, it is probable that the booster fan forced little warm air into the lower part of the room.

The temperature distribution within the test bungalow was ascertained by means of 200 thermo-couples enclosed in 3in cork spheres situated at five stations and five levels in each of the four large rooms, at three stations and five levels in each of the four large rooms, at three stations, and five levels in the bath, at suitable stations on the floor, in the ceiling surface, on the side walls, in the basement, in the attic, and out of doors. Additional thermo-couples of the parallel multiple-junction design were placed at the heater inlets and outlets. The absolute values of the heat transmitted to the attic were determined with the aid of twenty heat flow meters placed over the first layer of rockwool insulation in the attic. After steady state conditions had been maintained in outside and inside temperatures for approximately eight hours, test periods of about twelve hours were begun. Inside temperatures at approximately 150 stations were recorded at four-hour intervals. Hourly recordings were made of the following temperatures : outside air, 30in level at five room centres, five positions in the basement, five positions on the furnace, gas supply temperature, and one position in the wall cabinet. Gas consumption, electrical energy used for lighting the house, electrical energy consumed by the fan motors, and gas pressure were recorded hourly.

The test data do not provide specific answers to all questions that might be raised about gravity warm air heating of basementless houses. However, they do provide information on the temperature distribution produced by this heating system and offer some guidance in its application to smaller houses. The test results at an outdoor temperature of about —5 deg. Fah. show that the heater was able to produce a temperature of 70 deg. Fah. or higher at the 30in level in all rooms with either two or three supply grilles when the booster fan was in operation. With gravity circulation of the air under these conditions, it did not warm the two bedrooms and bath to 70 deg. Fah. at the 30in level. However, the temperature difference between the 2in and 60in levels was about 19 deg. Fah. with the booster fan in operation and 15 5 deg. Fah. with gravity circulation of the air. Experience with this heating system and with other systems indicates that people in the United States begin to experience discomfort if the temperature at the 2in level falls below 65 deg. Fah. or if the temperature at the 60in level exceeds 80 deg. Fah. By this criterion, at an outdoor temperature of —5 deg. Fah. some of the rooms would be too warm at the 60in level with the booster fan operating, and some would be too cold at the 2in level with gravity circulation.

Heating engineers commonly compute heat losses for dwellings on the basis of an indoor temperature of 70 deg. Fah. However, it is generally recognised that in the United States indoor temperatures ranging up to 75 deg. Fah. are preferred by normally clothed adults. It is probable that at the 30in level a 5 deg. Fah. variation of temperature between rooms would not be excessive as long as none of the temperatures was below 70 deg. Fah. or above 75 deg. Fah. and provided that the vertical temperature differences in the living zone were not excessive. By this criterion the temperature distribution attained in the test bungalow with the heater used for this investigation would hardly be acceptable at an outdoor temperature of —5 deg. Fah. but would be acceptable at an outdoor temperature of 15 deg. Fah. The results observed in the test bungalow with the test installation, for which the maximum distance between the heater outlet and the centre of any room did not exceed 11ft 6in, indicate that the limit of 18ft specified for this distance in the " Minimum Property Requirements " of the U.S. Federal Housing Administration is a liberal limit. The distance from the heater outlet to the centre of the coldest room was only 9ft. Probably few installations would have more favourable characteristics than the test installation for good distribution of heat by this method with respect to floor area, central location of the hallway, and central location of the heater. However, some larger houses could have a lower heat loss than the test bungalow if more insulation were used, thus decreasing the temperature difference between levels and between rooms. The computed heat loss of the test bungalow was about 51 B.Th.U. per hour per square foot of floor area for an indoor-outdoor temperature difference of 70 deg. Fah.

The heat loss of the test bungalow was computed using the method described in the Guide of the American Society of Heating and Air-Conditioning Engineers. On the average, the computed heat loss values were about 5 per cent higher than the observed values. In a particular installation of this kind the relation between computed and observed heat loss of a house would depend on whether the thermostat was set to produce a desired temperature in the warmest room or in the coldest room since there would probably be a temperature difference between rooms. For an indoor temperature of 70 deg. Fah. and an outdoor temperature of —5 deg. Fah. at the test installation, approximately 10 per cent more heat was required for the whole house when the coldest room was warmed to 70 deg. Fah. than when the warmest room was heated to 70 deg. Fah. It was concluded from the investigation of the specimen wall heater in the test bungalow that this class of heater—with or without a booster fan—should be used only in areas where the winter design temperature is 0 deg. Fah. or higher. However, application in colder climates might be satisfactory in some cases where the heat loss of the house is significantly lower than 50 B.Th.U per hour per square foot of floor area at the specified outdoor temperatures. This conclusion is based on observations made when the outdoor temperature was —5 deg. Fah. for which (1) the heater was not able to produce a temperature of 70 deg. Fah. at the 30in level in the centre of all the rooms without the booster fan, (2) the vertical temperature differences were as high or higher than the limit considered acceptable, and (3) the maximum temperature difference between the rooms was a little greater than 5 deg. Fah. at the 30in level and considerably greater than 5 deg. Fah. at other levels above the floor.

Personal and Business

Appointments

MR. W. H. GRINSTEAD has been appointed technical director of Siemens Brothers and Co., Ltd.

TECALEMIT, Ltd., Plymouth, announces the appointment of Mr. Gordon G. Goodwin as marketing manager.

MR. ROY BURGES has been appointed publicity manager of Birlec, Ltd., Tyburn Road, Erdington, Birmingham, 24.

THE LONDON MIDLAND REGION OF BRITISH RAILWAYS announces the appointment of Mr. J. W. Tonge as public relations officer.

EDGAR ALLEN AND CO., Ltd., Sheffield, announces the appointment of Mr. T. Samson as chief draughtsman in the track work department.

SIR CHARLES CUNNINGHAM and Mr. S. Collier have been appointed to the council of the Institute of General Managers, 86, Eccleston Square, London, S.W.1.

ARMSTRONG SIDDELEY MOTORS, Ltd., announces the appointment of Flight Lieutenant T. P. Frost as chief test pilot. Air Commodore H. M. Pearson has joined the company to undertake liaison duties with the R.A.F.

MR. H. E. G. HARVEY is shortly taking up an appointment as general sales manager of the British subsidiary of the Webster-Chicago Corporation. For the past four years he has been publicity manager of Ferodo, Ltd.

MR. JOHN DEXTER has been appointed general manager of Maycrete, Ltd., following the retirement of Mr. John Lintott from the position of managing director. Mr. D. R. Stanley-Adams has been appointed sales manager.

SHEEPBRIDGE ENGINEERING, Ltd., states that Mr. R. Dutton-Forshaw has been appointed a director. Mr. J. W. Lennox has been appointed general manager of Sheepbridge Alloy Castings, Ltd., in addition to his appointment as director and general manager of Sintered Products, Ltd.

METAL INDUSTRIES, Ltd., announces the following appointments to companies in the group :—Mr. G. P. Belsham, managing director of Brookhirst Switchgear, Ltd., Chester ; Mr. D. W. Kent, managing director of Igranic Electric Company, Ltd., Bedford ; Mr. E. Bruce Ball, director of Sentinel (Shrewsbury), Ltd., Fawcett, Preston and Co., Ltd., Finney Presses, Ltd., and Ferrous Castings, Ltd.; Mr. H. Murray Taylor and Mr. J. Lightbody, directors of Metal Industries (Salvage), Ltd., and Mr. J. Bruce, director of Shipbreaking Industries, Ltd.

Business Announcements

MR. E. BARNARD has retired from the position of deputy secretary in the Department of Scientific and Industrial Research.

HEAD, WRIGHTSON AND CO., Ltd., Thornaby-on-Tees, states that its Sheffield office is now at 46, Rutland Park, Sheffield, 10.

MR. J. F. GIST, governing director of A. Barton (Engineers), Ltd., Runcorn, is making a business tour of the Continent of Europe.

E. BOYDELL AND CO., Ltd., Manchester, states that its sole distributor in Belgium and Luxembourg is Ets. Andre Delaunois, 574, Chausee de Haecht, Brussels.

LAYCOCK ENGINEERING COMPANY, Ltd., Sheffield, has made an agreement with Knorr-Bremse, Munich, Germany, for the manufacture in this country of the latter company's air-braking equipment.

DR. THOMAS GIRTHIN has retired from the chairmanship of Johnson and Sons Smelting Works, Ltd. He has been a director of the parent company, Johnson, Matthey and Co., Ltd., since 1921.

SHEPPARD AND SONS, Ltd., Bridgend, announces an agreement with The Consolidated Mining and Smelting Company of Canada, Ltd., Trail, B.C., for manufacturing and supplying in this country the latter company's molten metal pumping equipment.

BIRLEC, Ltd., Tyburn Road, Erdington, Birmingham, 24, has made an arrangement with Otto Junker, Lammersdorf, Germany, and the Ajax Engineering Corporation, Trenton, U.S.A., for the development and marketing in this country of mains frequency coreless induction melting furnaces.

THE DAVID BROWN COMPANIES, Huddersfield, announce that plans are being made for tractor assembly and after-sales service facilities in South Africa. For this purpose a new company, David Brown Tractors S.A. (Pty.), Ltd., has been formed, with headquarters at East London, where a factory is to be established. Mr. R. M. Folly is the manager of the new company.

Contracts

DECCA RADAR, Ltd., has received a contract from the Admiralty for a new navigational radar for fitting in ships of the Royal Navy. The new radar will incorporate special features to meet the operational requirements of naval vessels and is designed, in particular, for manœuvring and pilotage purposes.

Miscellanea

LAND RECLAMATION.—We are informed that work is now in progress at the Stanlow oil refinery on the straightening of the River Gowy, which flows through the site. The length of the river is being shortened by 1000ft and the work, when completed in 1956, will enable the Shell Petroleum Company, Ltd., to recover about 11 acres of land.

ANHYDRITE MINE IN CUMBERLAND.—In the article entitled " Anhydrite Mine in Cumberland " (page 175, August 5th issue), we omitted to mention the name of the manufacturer of the belt conveyors and the feeder. We are glad to remedy this omission by stating that these equipments were supplied by Richard Sutcliffe, Ltd., of Horbury, Wakefield, Yorks.

MOTOR FUELS RESEARCH.—To discover more about vapour locking tendencies in hot temperatures a series of road tests has been carried out in Algeria by a team from the Sunbury Research Station of the British Petroleum Company, Ltd. Several makes of cars and various specially blended fuels were used and the results have been related to commercial fuels.

ROAD ACCIDENTS.—The statistics prepared by the Ministry of Transport and Civil Aviation for June and July, 1955, show that the total of motor vehicles registered at the end of June was 5,930,000, 10 per cent more than the year before, and that the total casualties for the preceding six months were higher by one eighth, 75 per cent of these being represented by slight injuries. However, total casualties among users of motor vehicles were higher by one fifth.

INDUSTRY AND TECHNICAL EDUCATION.—The Federation of British Industries has now published a full report of the conference on industry and technical education which was held at Loughborough last April. The report contains the text of the principal addresses delivered at the conference and summaries of the ensuing discussions. Copies of it (price 4s.) can be obtained from the Federation of British Industries, 21, Tothill Street, London, S.W.1.

EXCAVATOR EXPORTS TO CANADA.—A ceremony was held last week at the works of Thomas Smith and Sons (Rodley), Leeds, to mark the dispatch of the hundredth excavator made by the firm for Canadian purchasers during the past five years. This firm first entered the Canadian market in 1950 and since then despite heavy competition, it has sold machines and spares to a value of well over 1,500,000 Canadian dollars. The occasion was also marked by the dispatch of the hundredth excavator built by the firm since the war to New Zealand.

PIONEER SINGLE-DECKER PRESERVED.—The first vehicle of the Northern General Transport Company to have an underfloor engine, built by its chief engineer, Colonel Hayter, in 1935, and the first single-deck omnibus to carry forty-four passengers, was withdrawn from service earlier this year after completing 750,000 miles in the Newcastle to South Shields area. On August 25th the vehicle was driven by Mr. W. Richardson, the company's chief tester, from Newcastle to Norwood, South London, where it will be preserved in the old tram depot.

RESEARCH ON TIN.—The July issue of *Tin and its Uses*, the quarterly journal of the Tin Research Institute, Fraser Road, Greenford, Middlesex, includes a description of the researches carried out into the problem of bonding to steel backs the aluminium-tin bearings recommended for certain heavy-duty applications. The method adopted was that of rolling aluminium strip on and subsequently heating to 400 deg. Cent.; bearings based on this process are recorded to have run 200 hours without failure at 4500 lb per square inch loading.

IRRIGATION OF SUGAR BEET.—A demonstration of modern systems of irrigation equipment for sugar beet and other crops is to be held at Tixover, Rutland, on September 22nd, from 10 a.m. to 5 p.m. During the day there is to be a short meeting at which addresses, as follows, are to be given :—" Sources of Water for Farm Crops," by Dr. S. Buchan, of the Geological Survey ; " The Water Requirements of Sugar Beet and other Farm Crops," by Dr. H. L. Penman, and " The Irrigation of Farm Crops," by Mr. R. W. Ward. The demonstration is being organised by the British Sugar Corporation, Ltd.

LLOYD'S WRECK RETURNS.—We have received from Lloyd's Register of Shipping the returns for merchant ships totally lost, broken up, &c., for the quarter ended December 31, 1954. Steamships and motorships lost consequent upon casualty throughout the world totalled 62 ships of 92,858 tons gross and included 3 ships of 7914 tons owned in Great Britain and Northern Ireland and 7 ships of 1715 tons owned by the Commonwealth. The corresponding figures for ships lost not consequent upon casualty were respectively 146 ships of 324,707 tons gross, 46 ships of 54,206 tons, and 5 ships of 7531 tons.

INCREASING PRODUCTIVITY THROUGH WELDING.—The British Welding Research Association is arranging a number of meetings at various centres in Great Britain to discuss the general subject of " Increasing Productivity by the Use of Welding." The second of these meetings will be held at Electricity House, Colston Avenue, Bristol, 1, on Tuesday, October 4th, beginning at 9.30 a.m. The following papers, to introduce the discussions, are to be presented :—" Recent Developments in Welding Steel," by Mr. A. R. Muir ; " Welding Medium Carbon and Low-Alloy Steels," by Dr. C. L. M. Cottrell, and " Developments in Non-Destructive Testing," by Mr. A. L. Carson.

RUST REMOVING TOOL.—Demonstrations were recently given at the works of Jasons (Equipment), Ltd., Chertsey, Surrey, of a derusting tool which is made under licence from P. von Arx and Co., of Switzerland. This tool consists essentially of a pneumatic pistol, the piston of which actuates a group of hardened steel needles whilst they are pressed into contact with the surface to be cleaned. The hammering effect of the needle points quickly penetrates and breaks up the rust or scale on the surface being treated. The makers state that the amount of compressed air required to operate one of these tools is only 12·5 cubic feet per minute at 88 lb per square inch. Various diameters of needles and chisels can be fitted to the tool for descaling or stripping a variety of things such as iron oxide, plaster, concrete, or weld scale.

NAVAL ARCHITECTS' AUTUMN MEETING.—At the autumn meeting of the Institution of Naval Architects, to be held in Yugoslavia from September 19th to 25th, a programme of six papers is to be read at Opatija. On Tuesday morning, September 20th, Professor-Ing. S. Silovic and Ing. M. Fancev will present a paper entitled " Measurements in M.V. 'Rijeka,' with their Attempted Practical Application," and A. J. Sims, R.C.N.C., and A. J. Williams, R.C.N.C., will read a paper with the title " The Pitching and Heaving of Ships." Paper No. 3, " Frictional Drag of Smooth and Rough Ship," will be given by Ir. A. J. W. Lap. During the forenoon of Wednesday, September 21st, Ing. Djuro Stipetic will read his paper " Organisational Developments of the Shipyard Uljanik," and a paper entitled " The Recent Development of the Shipyard at Split " will be presented by M. Stanger and S. Ercegovic. The sixth and final paper of the meeting will be read by Dr. E. C. B. Corlett and entitled " On Design of Economic Tramp Ships."

PEAT FOR MAKING ACTIVATED CARBON.—The Northern Ireland Minister of Commerce has announced the completion of negotiations with the Seca Company, 175, Piccadilly, London, W.1, for the establishment of a new industry in the Londonderry area for the manufacture of activated carbon, using peat as a raw material. It is stated that the output from a new factory will represent the first United Kingdom source of peat-based activated carbon. A company entitled Seca (N.I.), Ltd., has been formed to operate the venture, with the participation of Charles Tennent (N.I.), Ltd., and it is planned to erect a factory on the outskirts of Londonderry. Production is scheduled to start in 1956. The establishment of this new industry results from the peat survey carried out by the Ministry's Department of Industrial and Forensic Science during the last three years. Samples of peat from various areas in Northern Ireland were examined and dispatched to the Seca Company for testing before a decision was reached to build the factory at Londonderry.

British Patent Specifications

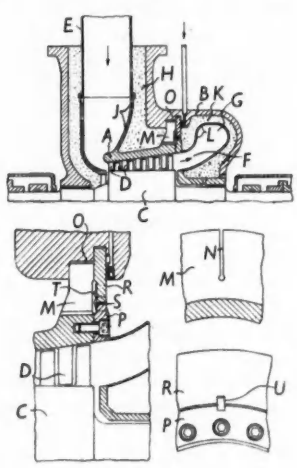
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

GAS OR STEAM TURBINES

733,537. August 12, 1953.—HOUSINGS FOR GAS OR STEAM TURBINES, Aktiengesellschaft für Technische Studien, Hardstrasse 319, Zürich, Switzerland.

The invention relates to a housing for gas or steam turbines which consists of an external housing and an internal housing, both of which can be divided in an axial plane. As will be seen from the drawing, the turbine housing comprises an internal housing *A* and an external housing *B*. Mounted in the housing is a rotor *C*. The internal housing supports the guide blades *D*. The flowing medium enters through a tube *E* connected to the internal housing, expands in the blading of the turbine and leaves it through a diffuser *F* and an adjoining discharge chamber *G*. The internal housing defines with the external housing an intermediate space *H* containing insulating material. The intermediate space communicates through apertures *J* with the inlet chamber of the internal housing *A*, so that the same pressure obtains in the intermediate space as in the inlet tube *E*. On the outlet side of the turbine, on the other hand, the external housing surrounds a space *K* containing



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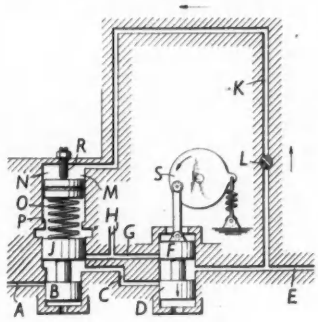
insulating material, which communicates with the discharge chamber *G* through apertures *L*. The internal housing *A* comprises a flange *M* having radial slots *N* at various points along its periphery. The flange engages in a slot *O* in the external housing *B*. *P* and *R* are two coaxially arranged one-part rings having between them a radial clearance *S*. The inner ring *P* is rigidly connected to the low-pressure end of the internal housing by screws as shown. The outer ring *R*, on the other hand, engages, together with the supporting flange *M*, in the slot *O* of the external housing *B*. *T* is a thin corrugated sealing plate, which is connected to the two rings and bridges the clearance *S* between them. Owing to the radial slotting, no annular stresses are set up in the supporting flange. The flange is substantially unaffected by a radial temperature drop, and thermal stresses are avoided. The flange portions situated between the slots can expand freely in the radial direction. A good sealing of the space between the internal housing and the external housing is effected with the aid of the rings *P* and *R*. Some thermal stresses are set up in these rings, but owing to the subdivision into two rings these thermal stresses are kept within permissible limits, since each ring can expand independently. The two rings may be centred in relation to one another by three keys *U*, one of which is shown in the lower right-hand view.—*July* 13, 1955.

HYDRAULIC MACHINES AND APPARATUS

733,335. May 24, 1951.—HYDRAULIC PRESSURE-REGULATING APPARATUS, The Sperry Gyroscope Company, Ltd., Great West Road, Brentford, Middlesex. (*Inventor: Dennis Lincoln Spencer.*)

The invention relates to hydraulic installations for supplying liquid at an operating pressure to hydraulic utilisation apparatus, such as the servo-motor of an automatic control system. The drawing shows a diagram of a hydraulic pressure-regulating apparatus, in which the various valves are piston valves. When the system is switched on by opening of the valve *D*, liquid will flow through the inlet channel *A* by way of the regulating valve *B*, which will be open by virtue of the unopposed thrust of the spring *O*, to channel *C*, cut-off valve *D*, and outlet channel *E*. The presence of pressure liquid in the chamber between the valve *B* and piston *J* produces a thrust tending to close the valve *B* by virtue of the greater area of the piston *J*. This thrust is opposed by the spring *O* acting on the other side of the piston *J* and bearing against the piston *N* which rests against the screw *R*. Thus, pressure builds up in the channels *C* and *E* to a value that is determined approximately by the force exerted by the spring *O* when valve *B* is just closed. Liquid at this pressure is led by way of feed-back channel *K* to the chamber *M*, but by reason of the restrictor *L* the pressure builds up slowly, the rate of build up being determined by the setting of the restrictor. As the pressure builds up in the chamber, the piston *N* is forced towards the valve *B*



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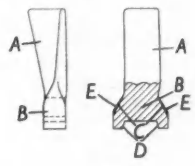
and piston *J*, and compresses the spring *O*, whereupon the valve *B* opens and does not close again until the pressure in the chamber between pistons *B* and *J* balances the increased force in the spring *O* when the valve *B* approximates to the closed position. Thus, the pressure in the channels *C* and *E* builds up due to the decreased pressure drop in the regulating valve *B* and the further increase is gradually built up in the chamber *M*, so that the regulating valve *B* is further opened. The system becomes stabilised when the force tending to close the valve *B* due to the liquid acting on the greater surface of the piston *J* is balanced by the additional thrust in the opposite direction due to compression of the spring *O*. This thrust is limited to a maximum by the stops *P*, which limit the movement of piston *N*. Thus it will be seen that on opening the cut-off valve *D* to switch the system on, the build up of pressure in the outlet channel *E* will be slow and the output pressure will not reach its full value until the regulating valve *B* has been fully opened due to the build up of the pressure in the chamber *M*. When it is desired to shut the system off, the clutch *S* is operated to close the cut-off valve *D* and open the exhaust valve *F* to connect the outlet channel *E* to the exhaust channel *G*. Reduction of pressure in the outlet channel *E* allows the contents of the chamber *M* to decrease slowly by way of the restrictor *L*, and the piston *N* to rise until it reaches the stop *P* and the system is returned to its initial state. When applied to the servo-motor controls of a hydraulic automatic system for controlling the direction of flight, or the attitude of an aircraft, it ensures that, immediately after switching on, the system operates with only comparatively low pressure liquid, so that only relatively weak control actions are exercised. This affords the pilot time to observe the functioning of the automatic pilot for a period in which he can still override the automatic control system by manual control. Furthermore, the automatic pilot takes over control in a smooth and gradual manner should there be initially some small difference between the attitude of the aircraft and the attitude set for it on the automatic control system.—*July* 13, 1955.

GAS TURBINES

734,157. August 21, 1953.—CERAMIC ROTOR BLADES FOR AXIAL FLOW TURBINES, COMPRESSOR AND PUMPS, Maschinenfabrik Augsburg-Nurnberg A.G., Stadtbachstrasse 7, (13b) Augsburg 2, Germany.

The invention relates to a ceramic rotor blade for axial flow turbines, compressors and pumps and, in particular, to a ceramic blade for gas turbines, and steps for utilising to the fullest extent, in these ceramic machine parts, the maximum mechanical strength attainable in the material employed. A rotor blade *A* of a gas turbine, shown in the drawing, is made of heat-resistant ceramic material. The root *B* of the blade has two pairs of supporting surfaces for the purpose of holding the blade in a blade slot in the rotor, in a manner which is independent of temperature, the fixing being positive for all working conditions of the turbine. A pair of seating surfaces *C* are loaded in operation by centrifugal forces acting upon the blade, whilst the pair of counter-surfaces *D* have a function which is exclusively supporting, ensuring the maintenance of the connection of blade root and rotor disc by shape. A special protective layer *E* is applied to each surface of the pair of seating surfaces *C*, the layer *E* having a foamy porous



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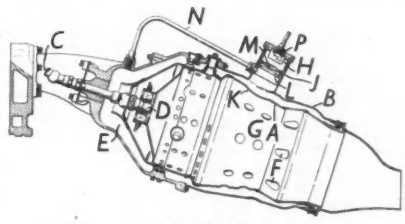
structure after the ceramic firing. This protective layer is applied in adequate thickness to the supporting flanks of the blade root *B*. If the blade root has already been provided with a compact glaze for increasing the strength of the constructional part, it will be sometimes sufficient to apply to this coating the second protective layer by scattering or brushing on the ceramic composition suitable for this purpose. After this application, the ceramic blade is subjected to firing. A completely ceramic turbine blade made in this way has the advantage of being free from all extraneous materials and, by means of the porous protective layer, according to the invention, of being able to impede sufficiently the flow of heat to the rotor disc.—*July* 27, 1955.

734,020. July 16, 1952.—THE COMBUSTION OF FUELS, The Sperry Gyroscope Company, Ltd., Great West Road, Brentford, Middlesex. (*Inventors: Douglas George Downes and Peter Hobley.*)

The invention relates to control of the conditions of the combustion of fuels in internal combustion engines and multi-chamber gas turbines for aircraft propulsion. It is particularly concerned with the control of the ratio of fuel/air. In the drawing is shown a combustion chamber of a gas turbine for aircraft propulsion which is provided with apparatus responsive to a light characteristic of the flame in the chamber. Combustion takes place inside an inner chamber *A*, which is positioned within an outer chamber *B*. Fuel is supplied by way of the passage *C* to a nozzle *D* through which it is introduced into the inner chamber *A*. Air from the compressor is supplied to the region *E* which is in communication with the inner chamber *A*, and with the space between the inner chamber and the outer chamber. The secondary air enters the inner chamber at or near the end of the flame through ports *F*. In order that a light characteristic of the flame in the inner chamber *A*, at a chosen region, for example, *G*, may be observed, a photo-electric cell *H* is mounted at one end of a tube



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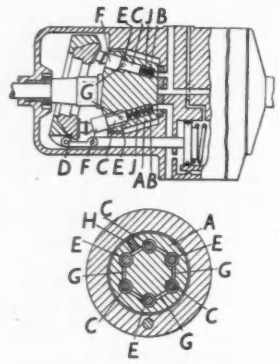
J, the other end of which opens into the outer chamber *B*. Opposite the opening into the outer chamber is an aperture *K* in the wall of the inner chamber *A*. Between the wall of the outer chamber and the photo-electric cell *H* is positioned a colour filter *L* and a lens *M* through which light from the combustion chamber must pass before it can reach the photo-electric cell. The lens is arranged so that light from the flame is focused on the light-sensitive electrode of the cell. The colour filter is designed in accordance with the light characteristic to which the cell is required to be responsive. A passage *N* is provided by means of which secondary air can flow from the region *E* into the end of the tube *J* between the colour filter *L* and the well of the outer chamber *B*. This flow of air prevents ash and dirt from the combustion chamber obscuring the surface of the colour filter. Assuming that it is found by preliminary experiments that the fuel/air ratio under which combustion is taking place is the desired ratio when the intensity of light of a certain wavelength emitted from the region *G* of the flame is at a maximum, the colour filter will be designed to pass light of that wavelength to a greater extent than light of other wavelengths. It will be clear that the photo-electric cell *H* will be greatly excited or only slightly excited according as the fuel/air ratio in which

combustion takes place is, or is not, the desired ratio. The output from the photo-electric cell is connected by leads *P* through an amplifier to electrical apparatus associated with a valve in the fuel supply line, and it can be arranged that when the output from the photo-electric cell *H* is greater than a certain value, the valve will be operated to reduce the rate of supply of fuel. An example of such a valve is also shown in the specification.—*July* 20, 1955.

PUMPS

734,606. November 29, 1952.—Reciprocatory Pumps, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventor : Frank George Freeman.*)

The invention relates to pumps of the swash plate kind having two or more reciprocatory plungers individually contained in corresponding bores, and particularly pumps for supplying liquid fuel to jet engines, gas turbines or reciprocatory piston engines.



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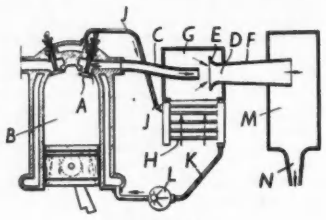
It comprises a pump in which there is combined with each plunger a piston and cylindrical cavity of larger diameter than the plunger, the cavities associated with the different pistons being in communication with each other, and the arrangement is such that liquid displaced by the piston or pistons moving inwards is utilised to effect or ensure the outward movement of the other piston or pistons. Referring to the drawing an application of the invention to a swash plate pump is shown, comprising a rotor *A* having within it a number of bores *B* each of which contains a plunger *C*. Inward movements of the plungers are effected by contact of their outer ends with a stationary swash plate *D*, and a cylindrical cavity *E* is formed in the rotor at the outer end of each bore. Also on the plunger is formed a piston *F* which is slidable in the cavity, the piston and cavity being made of appropriately larger diameters than the plunger. Further, all the cavities are in communication with each other through passages *G* in the rotor, as shown in the lower view. Initial filling of the cavities may be effected in any convenient manner, as, for example, through a hole in the rotor, which is subsequently closed by a plug H. The arrangement is such that when one or more of the plungers is moving inwards under the action of the swash plate, the fuel or other liquid contained in the cavities *E* is transferred through the passages *G* to the cavities associated with the outward moving plungers. The pressure exerted by the displaced liquid is such as will ensure the outward movements under conditions which would otherwise result in stalling. If desired, a spring *J* may be combined with each plunger for supplementing action of the displaced liquid, but this is not essential. The invention is applicable in a similar manner to reciprocating pumps of the kind in which the plungers are contained in the bores of a stationary body part, and are operable in one direction by a rotary swash plate, but it is not, however, restricted to the particular construction described.—*August* 3, 1955.

INTERNAL COMBUSTION ENGINES

734,626. March 11, 1953.—Circulation of Air to Cool a Multi-Cylinder Engine, Société Nationale D'Etude et de Construction de Moteurs D'Aviation, 150, Boulevard Haussmann, Paris, France.

According to the invention there is provided a device which promotes circulation of air in a system acting to cool a multi-cylinder internal combustion engine characterised in that a separate exhaust pipe is provided for each of the cylinders and is combined with an individual ejector tube, the outlet end of the exhaust pipes and the suction side of the ejector tubes being disposed within a common suction chamber forming part of the cooling system. In the drawing the invention is shown applied to a four-stroke, four-cylinder engine. The exhaust valve *A* of each of the cylinders *B* opens into an exhaust pipe *C* which is short, has no sharp bends and the cross-sectional area of which, according to circumstances, lies at one or other point between the maximum passage area afforded by the valve when it is open, and the mean value of the passage area during the exhaust period. This pipe *C* delivers the exhaust gases to an ejector tube *D* comprising a short convergent section *E*, followed by a relatively long divergent section *F* of relatively small cone



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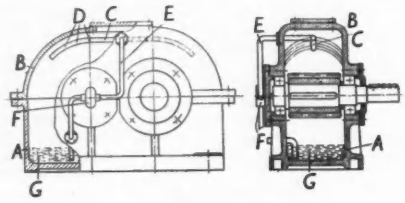
angle. There is a tubular member and an ejector tube for each of the cylinders of the engine. The convergent parts or suction sides *E* of the ejector tubes and the outlet ends of the pipes *C* open into a common suction chamber *G* which communicates with the atmosphere over the cluster of tubes *H* of the radiator, through which passes the cooling water of the engine, which is thus cooled by the circulation of air past the tubes *H*. The hot water is taken off from the top of the water jacket of the cylinder group by the pipe *J*, passes through the cluster of tubes *H* and returns through a pipe *K* and a pump *L* to the base of the water jacket, the whole system thus acting to cool the engine. The ejector tubes *F* all discharge into a common exhaust chamber *M* with a convergent nozzle *N* to the atmosphere. The scavenging of a two-stroke air-cooled engine is also described in the specification.—*August* 3, 1955.

POWER TRANSMISSION

734,564. October 2, 1953.—Gearboxes, Alfred Friedrick Flender, trading as A. Friedr. Flender and Co., of 58, Kaiser Wilhelm Strasse, Bocholt/Westphalia, Germany.

The invention relates to gearboxes and the object of the invention is to improve the cooling of gearboxes, and a gearbox is provided in which there is a spraying arrangement for cooled liquid. As the drawing shows,



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the oil-spray apparatuses are situated within a completely assembled lower part *A* of the gearbox, which is screwed to the gearbox lid or upper part *B* and can be constructed in the form of a spray or jet nozzle, a sprinkler or preferably a spray tube *C* having a series of adjacent outlet apertures *D* arranged in a row or rows. Each of these oil-spray devices are in communication with one or more oil supply tubes *E* through which the cooling oil is circulated by a pump *F*. The oil simultaneously serves as lubricant for the gearing. The oil wets the gearbox over its entire width and therefore partly carries off the heat in the walls. From the oil sump the oil, which has become heated, is conveyed to any desired cooling system before recirculation. In this way, the heat which is produced as a result of the bearing friction and by the friction within the gearing system and which is partly given off to the longitudinal walls of the gearbox, is continually carried off.—*August* 3, 1955.

Catalogues and Brochures

Bailey Meters and Controls, Ltd., Purley Way, Croydon.—Leaflet E.500 giving details of Bailey miniature equipment for temperature flow, pressure level and draught.

The Expanded Metal Company, Ltd., Burwood House, Caxton Street, London, S.W.1.—Folder describing "Expamet" load testing equipment and electric air heaters.

J. Clubley Armstrong Danarm, Ltd., Abford House, Wilton Road, Westminster, London, S.W.1.—Descriptive leaflet on the Danarm "Fury" one-man petrol-driven chain saw.

Tube Investments, Ltd., The Adelphi, London, W.C.2.—Booklet, "This is T.I. To-day," giving an up-to-date list of Tube Investments' companies and their main products.

Maschinenbau Kiel Aktiengesellschaft.—Illustrated folders describing the "MAK" diesel-hydraulic locomotives, types "800 D," and "240 B" or "240 C" and other diesel locomotives, railcars and rail motor coaches manufactured by this company.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 28th.—London Section : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Extending the Limits of Resistance Measurement Using Electronic Techniques," G. I. Hitchcox, 6.30 p.m.

ENGINEERING INDUSTRIES ASSOCIATION

Wed. to Fri., October 12th to 14th.—Royal Horticultural Society's New Hall, Greycoat Street, London, S.W.1, Eighth London Regional Display.

ENGINEERING, MARINE AND WELDING EXHIBITION AND THE FOUNDRY TRADES EXHIBITION

Tonday to Thurs., Sept. 15th.—Olympia, London. Open each weekday from 10 a.m. to 8 p.m.

ILLUMINATING ENGINEERING SOCIETY

Fri., Sept. 23rd.—Bath and Bristol Centre : S.W. Electricity Board, Old Bridge Street, Bath, "Interior Decoration and its Effect upon Illumination," J. D. Layton, 7 p.m.——Birmingham Centre : Regent House, St. Phillip's Place, Colmore Row, Birmingham, Chairman's Address, G. R. Hanson, 6 p.m.
Mon., Sept. 26th.—Leeds Centre : Chemistry Lecture Theatre, The University, Leeds, "The Brightness of the Stars," Sir Harold Spencer Jones, 7 p.m.——Leicester Centre : E. Midlands Electricity Board, Charles Street, Leicester, "Interesting Lighting Jobs," Papers by Members, 6 p.m.
Wed., Sept. 28th.—Transvaal Centre : Room 95, Public Library, Johannesburg, "The Study of Natural Daylighting Using Models," W. M. H. Rennhakkamp, 8 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Sept. 12th.—Dundee Branch : Mathers Hotel, Dundee, "The Use of Breathing and Resuscitating Apparatus," 7.30 p.m.
Thurs., Sept. 15th.—Blackburn Branch : Golden Lion Hotel, Blackburn, "Corrosion—Prevention and Control," G. Butler, 7.30 p.m.
Wed., Sept. 21st.—Kent Branch : Bull Hotel, Rochester, "Building Construction for Industry," 7 p.m.——Western Branch : Grand Hotel, Bristol, "Coal and Oil." 7.15 p.m.
Mon., Sept. 26th.—W. and E. Yorks Branch : The University, Leeds, "Axial Flow Fans," R. H. Holbeche, 7.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Sept. 14th.—26, Portland Place, London, W.1, "Modern Crude Oil Loading Techniques at Mina-al-Ahmadi, Kuwait," J. M. Dougary, 5.30 p.m.

INSTITUTE OF PHYSICS

Fri. and Sat., Sept. 23rd and 24th.—Electronics Group : 47, Belgrave Square, London, S.W.1, "Some Recent Developments in Magnetic Materials," Symposium.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, Sept. 9th.—South Wales Group : South Wales Institute of Engineers, Park Place, Cardiff, "An Approach to the Organisation and Operation of a Large Composite Fleet," R. H. Patman, 7 p.m.
Mon., Sept. 12th.—E. Regional Centre : Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, "The Selection and Maintenance of Light Commercial Vehicles," C. D. H. Stead, 7.30 p.m.
Tues., Sept. 13th.—W. Regional Centre : Adelphi Hotel, Lime Street, Liverpool, "Gregoire Suspension," J. Clifford, 7.30 p.m.
Thurs., Sept. 15th.—Yorkshire Centre : Great Northern Hotel, Welling Street, Leeds, 1, "Multi-Purpose Lubricating Oils," P. H. G. Crick, 7.30 p.m.
Tues., Sept. 27th.—N.E. Centre : Three Tuns Hotel, Durham, "Gas Turbine Development for Road Transport," P. A. Phillips, 7 p.m.

INSTITUTE OF WELDING

Wed., Nov. 2nd, to Fri., Nov. 4th.—Autumn Meeting, London.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Oct. 12th.—St. Bride Institute, Bride Lane, Fleet Street, London, E.C.4, Presidential Address, R. L. Quertier, 6.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 21st.—General Meeting : Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Presidential Address, K. J. Cook, 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Oct. 4th.—Ordinary Meeting : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Radio Aids to Marine Navigation," W. Dolman, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Sept. 12th.—Manchester Graduate Section : Reynolds Hall, College of Technology, Sackville Street, Manchester, "The Gas Turbine Locomotive," P. E. Stock, 7.15 p.m.
Wed., Sept. 14th.—Dundee Section : New Imperial Hotel, 15, Tally Street, Dundee, "The Practical Application of Production Engineering Research," D. F. Galloway, 7.30 p.m.
Mon., Sept. 19th.—Sheffield Graduate Section : The Inspection Establishment, Jansen Street, Sheffield, "Screw Thread Gauging," 6.30 p.m.——N.E. Section: Neville Hall, Newcastle upon Tyne, Address by Section Chairman, F. Baker, 7 p.m.——Manchester Section : Reynolds Hall, College of Technology, Manchester, "Lubrication," H. E. Priston, 7.15 p.m.

IRON AND STEEL INSTITUTE

Wed. to Fri., Oct. 12th to 14th.—Special Meeting in Scunthorpe.

SHEET AND STRIP METAL USERS' TECHNICAL ASSOCIATION

Mon. and Tues., Oct. 10th and 11th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, Special Conference on Modern Materials.